A HISTORY OF AMERICAN MINING

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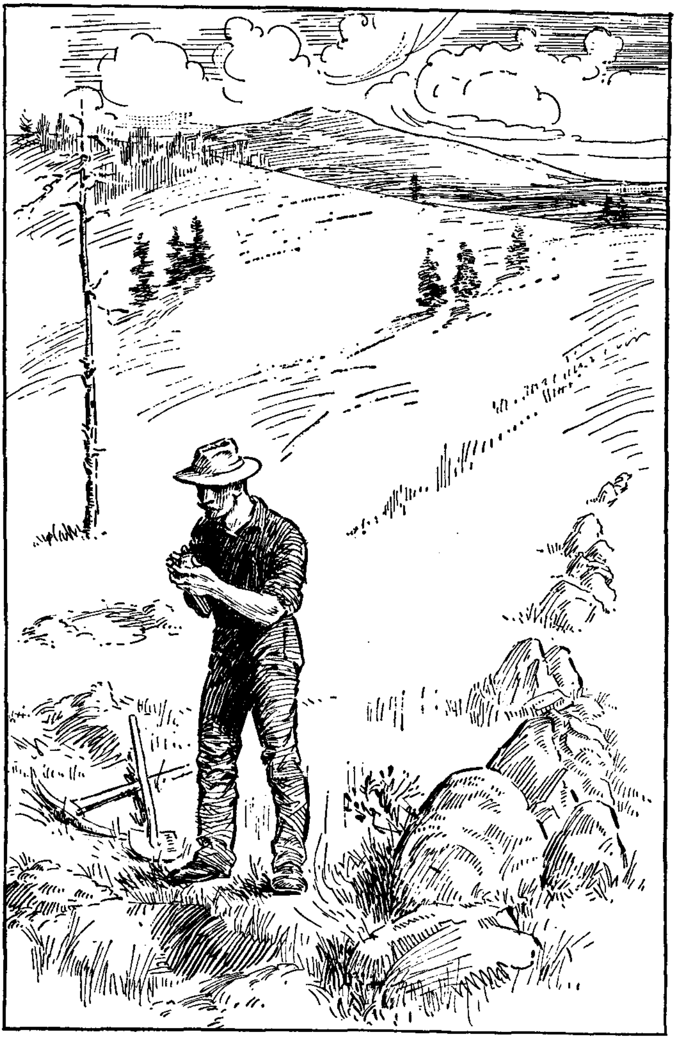
TO THE MOST DISTINGUISHED OF AMERICAN MINING ENGINEERS

HERBERT HOOVER



(*Frontispiece*)

Stratton discovering the Independence.

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INTRODUCTION

This volume forms the second of the series issued by the American Institute of Mining and Metallurgical Engineers and made possible through the Seeley W. Mudd Memorial Fund. It is designed to give to those who have come late into the professions of mining engineering and metallurgy something of that background the older men built up as they went along. The pioneers did not read history; they made it. We who come later, facing different and more complex situations, have much to learn from their experiences. In developing the mineral wealth of a continent and building a great industry things do not "just happen"; they are brought about by men who have the wit to see and the courage to do. Our predecessors were men with these qualities. They fought great battles against heavy odds and they have left us a great heritage. Many of them we cannot know in person for they have "gone over the range," but we do well to know what they did and how they did it.

Too much of history as taught in schools is concerned only with war and political changes. Fortunately wars come but infrequently while we must eat every day. Fortunately, also, but few attempt to make their living out of politics. Most of us are concerned with other things, and engineers first of all with those things which center on the technology and economics of their profession. To understand these we need a historical background: we must know how things come about.

In this book Mr. Rickard breaks ground. It is true pioneering since little has been written on the history of any engineering in America and less on that of mining. Mr. Rickard has not attempted to write a complete or even a systematic historical work. Instead he has opened doors and invited

his readers to glimpse fascinating vistas of the past. For those who wish to pursue the subject further abundant footnotes have been provided, and those who miss chapters on regions and materials not covered may be reminded that the field is open and a good example is well followed. What Mr. Rickard has written has to do mainly with the West; it is part of the story of how our country came to be and as such should be part of the intellectual equipment of every engineer who aspires to have a part in the making of tomorrow.

It is particularly fortunate that it has been possible, through the generosity of the author, to include this book in the series. No one could have been found more competent to prepare it than Mr. Rickard, nor anyone more willing to assist in furthering the generous intention of the benefaction. Mr. Rickard first met Mudd in 1886 and has taken particular pleasure in writing this book. Its production is one more evidence of the high esteem in which Mudd was held by his professional associates and the compelling force of the ideal of service which shaped his life. Mudd was himself a Westerner. Born and educated in Missouri, he devoted the larger part of his professional activities building up mining in the Trans-Mississippi region. His first job after he had been graduated from Washington University was at the copper smelter in Ste. Genevieve in the Ozarks. Later he moved to Colorado and still later to the Southwest. He played an honorable part in the development of a number of the great mines of the region and he left to his profession a lasting heritage of good will and high ideals.

H. FOSTER BAIN.

NEW YORK, N. Y.,
June, 1932.

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A HISTORY OF AMERICAN MINING

CHAPTER I

THE BEGINNING

The American mining industry is vigorous today because it is young. At a time when the ore deposits of central Europe, for example, were being exploited actively, those of the United States were lying practically untouched. The founding fathers of our republic were not interested in mineral wealth because they were ignorant in such matters; their preoccupations were with defence against the Indians, the clearing of the forest, and the starting of agriculture in their new domains. They had no idea of establishing a mining industry.

The Indians whom the American colonists dispossessed had no mines; they used only the metal that was to be found lying on the surface of the ground. Their arrows and spears were tipped with flint, which likewise called for little digging, if any. The native copper that glacial action had torn from the lodes of the Lake Superior region and had carried into the valleys of the Ohio and Mississippi was employed in the making of ear-rings, bracelets, knives, and scrapers. The same useful metal was found in many other places, in Virginia and Carolina, in Vermont and New Jersey, for example, but the Indians did not know how to melt it, much less how to smelt the ore, therefore they shaped it into tools and implements by hammering. Fortunately for them the hammering of the metal caused it to harden and therefore to become serviceable for implemental use. It is doubtful if they obtained the copper by actual mining, that is, by digging or excavating; it is true we find traces of such operations in the Keweenaw peninsula of Michigan, but we have no

evidence that such operations antedated the arrival of the first Europeans.

How little the future greatness of the United States as a mineral region was anticipated, or even imagined, in the eighteenth century is evident from a remark made by a Dutch philosopher, Cornelius de Pauw, who, writing in French, stated that "in all the extent of America there are found but few mines of iron, and these so inferior in quality to those of the old continent that it cannot even be used for nails".* In 1929 the United States produced 56,433,000 tons of steel.† Even that wise philosopher Benjamin Franklin, when arguing in favor of a paper currency in 1790, remarked: "Gold and silver are not the produce of North America, which has no mines".‡ In 1929 our production of gold was worth $43,900,000, and that of silver amounted to 60,938,000 ounces. In 1915 we produced $101,035,700 in gold, and in 1923 the output of silver was 73,335,170 ounces.

It is true, nevertheless, that the early exploration and colonization of Massachusetts and Virginia were stimulated by the belief that these regions were rich in the precious metals, as likewise they had been a lure for the Spaniards in the southern regions of the American continent. The British Crown, like the Spanish, had an eye to a share in any gold or silver that might be found in the New World; in 1606 the charter granted by James I to the London and Plymouth companies specified that a fifth of the precious metals and a fifteenth of any copper that might be discovered by the settlers in the course of their explorations should accrue to the Crown. It is said that John Smith, when he arrived in Virginia, sought gold and copper mines, and would be content with fur and fish only in default of the more valuable metallic products.§

* Cornelius de Pauw, 'Recherches Philosophiques sur les Américains', Vol. II, p. 182; 1770.

† *Mineral Industry,* edited by G. A. Roush, Vol. XXXVIII; 1930.

‡ 'The Works of Benjamin Franklin', edited by Jared Sparks, Vol. II, p. 347; 1840.

§ Herbert I. Priestley, 'The Coming of the White Man', p. 10; 1929.

In one of his expeditions, up the Chickahominy river, Captain Smith is said to have found some gold, the consequence of which was to cause much excitement in the colony and the sending of a shipload of glittering dust to the jewelers in London, who reported that it was only mica. Tales of natives wearing golden ornaments were told of the aborigines of New England as had been said, more truthfully, of the peoples whom Cortés and Pizarro dispossessed. All that the northern Indians could show in the way of metal was native copper, which, according to the early explorers, they wore as ear pendants, necklaces, and bracelets, besides making tobacco-pipes out of it. These, however, were hereditary accumulations and did not bespeak any important industry. Franklin said that he knew of only one copper mine in the country; it was in New Jersey. In 1929 the United States produced 931,103 tons of copper.

Copper in the metallic, or native, state was used by the aborigines of North America before the arrival of any Europeans. For example, Sebastian Cabot, in 1497, saw the natives of Newfoundland in possession of "great plenty of copper", which they wore as "beadstones hanging at their ears".* When Giovanni Verazzano, a Florentine navigator sailing under the French flag, reached Nantucket island in 1524 he found the Indian women wearing ornaments of wrought copper, which they esteemed more than gold.† Jacques Cartier,‡ on the occasion of his second voyage to Canada, in 1535, when exploring the river St. Lawrence, was given "a great knife of red copper that commeth from Saguenay", this being native copper that had been hammered by the Indians. Samuel Hearne, in 1771, went to the Coppermine River dis-

* Richard Hakluyt, 'The Principal Navigations, Voyages, Traffiques, and Discoveries', Vol. VII, p. 153; 1904.

† John R. Forster, 'History of the Voyages and Discoveries made in the North', p. 435; 1786.

‡ Richard Hakluyt, 'The Third and Last Volume of the Voyages', p. 230; 1600.

trict, and ascertained there that the Eskimos of Coronation Gulf, on the Arctic coast, came thither to dig for native copper, which they found in a conglomerate and with which they made knives, awls, and spearheads.* George M. Douglas visited this district in 1912 and found the Eskimos still using the copper in the same lithic way. Occasionally they discover a piece large enough to beat into a knife 8 inches long and 3 inches wide.† They possess no tools for mining, and therefore are restricted to grubbing for pieces of metal that have been set free by the weathering and decomposition of the encasing rock. That is how primitive man, thousands of years ago, obtained some of his copper.

The early European navigators that visited the Pacific coast of British Columbia and Alaska found the natives in possession of copper bracelets‡ and ceremonial plates.§ The Russian explorers in Alaska, near Mount St. Elias, found crude copper knives in the Indian huts as early as 1741.‖ The Haidas, on the Queen Charlotte islands, were the principal traders in copper on the North Pacific coast and had a tradition of obtaining it from a copper mountain in the north. The same tradition survived among the Chilkats, at the head of the Lynn Canal. They obtained their copper from the White river, in the Yukon watershed. Sixty years ago the Indians were still using the metal as an article of trade, and were secretive as to its provenance. Specimens had a worn appearance as if eroded by stream action, says Dall.¶ He remarks that the copper occasionally showed silver also, which

* George M. Douglas, 'Lands Forlorn', p. 284; 1914.

† Samuel Hearne, 'A Journey from Prince of Wales' Fort in Hudson's Bay to the Northern Ocean', edited by J. B. Tyrrell, p. 198; 1911.

‡ John Ledyard, 'A Journal of Captain Cook's Last Voyage', p. 77; 1783.

§ 'Menzies' Journal of Vancouver's Voyage', edited by C. F. Newcombe, p. 42; 1923.

‖ S. Muller, 'Voyages from Asia to America', translation from the Dutch by Thomas Jefferys, p. 42; 1761.

¶ William H. Dall, 'Alaska and Its Resources', p. 477; 1870.

indicates that it came from the Dan and Chitutu rivers, where such silver-copper nuggets are still obtained in association with alluvial gold.* This is the part of Alaska now known as the Chitina, or Copper River, district. *Chiti* is copper and *na* is river in the Indian language.† Here we may take note of the fact that many of the dialects of the Alaskan aborigines have the word for copper, but none for gold or for iron. Spearheads and arrowheads made by the Indians out of native copper have been found by American miners in the sluice-boxes of their placer workings on the tributaries of the Chitina river. The Indians on the White river, 125 miles east of the Copper river, used caribou horns to dig the copper nuggets out of the stream gravel;‡ in later days they bartered this native copper, which was used by themselves and other tribes for arrowheads, knives, and cooking utensils, and also for bullets when lead was not obtainable.§ One mass of three tons was found on a bank of the White river, but most of the copper was in the form of lumps weighing about five or six pounds.|| It was the only metal these Indians used when the fur-traders first came in contact with them. The English colonists also availed themselves of native copper, as we shall see.

The first copper-mining in American lands was at the Cobre mines in the Santiago province of Cuba in 1524.¶ These mines were worked irregularly until 1834, when an English company bought and consolidated the principal claims; they have been operated in recent years under American control.

* Fred H. Moffit, U. S. Geol. Survey, *Bull.* No. 345, p. 175; 1908.

† Fred H. Moffit and A. G. Maddrew, 'Mineral Resources of the Kotsina-Chitina Region, Alaska', U. S. Geol. Survey, *Bull.* No. 374, p. 19; 1909.

‡ A. H. Brooks, 'A Reconnaissance from Pyramid Harbor to Eagle City, Alaska', U. S. Geol. Survey, *Annual Report*, Vol. XXI, p. 379; 1899.

§ D. D. Cairnes, 'Upper White River District, Yukon', Canadian Geol. Survey, *Mem.* No. 50, p. 2; 1915.

|| C. W. Hayes, 'An Expedition through the Yukon District', *National Geographic Magazine*, Vol. IV, p. 143; 1892.

¶ E. G. Tuttle, *Mines and Minerals*, Vol. XXXI, p. 449; 1911.

A copper lode was discovered in Massachusetts in 1632, but the first company in the American colonies that was chartered to exploit copper deposits was the one organized by John Winthrop, the younger, in 1709, to start mining at the town of Simsbury (now East Granby) in Connecticut, where a copper lode had been discovered two years previously. This mine was worked until 1773. Shafts were sunk to a depth of 80 feet, and "vast caverns excavated in the hill",* but the lack of machinery and the cost of pumping reduced profits sadly. A smelter is said to have been erected by the German workmen at a place in West Simsbury that they named Hanover. After the Revolution the mine became the State prison of Connecticut, and was used for this purpose until 1827.† The mine was not profitable except at first, when rich ore was obtainable, the colonists shipping it to England, because, at that time, the smelting of it in the colonies was prohibited.‡ The cost of transport was high and the ships that carried the ore were sometimes wrecked and occasionally seized by the French during times of war. When the mine was abandoned, its capacious openings were utilized as a prison for felons, and later for the unfortunate Tories. It is now known as Newgate, in compliment to the famous prison in London. As Dr. J. H. Trumbull observes, in this way the mine "became of much greater value to the State than all the copper dug out of it". The memory of the enterprise is perpetuated by the coins that were struck from the copper in 1737 and 1739. These coins were never legal tender, but served as token money, because small change was scarce in the colonies at that time.

It is interesting to note that the manufacture of pins from native copper by wire-drawing artificers from Yorkshire was

* J. Leander Bishop, 'A History of American Manufactures', Vol. I, p. 508; 1861.

† 'Newgate of Connecticut', *Magazine of American History*, Vol. XV, April, 1886.

‡ Bishop, *op. cit.*, p. 509.

started at Lynn in 1666 by Nathaniel Robbinson, and the General Court gave a small monetary aid to encourage the undertaking.

Meanwhile other mines had been started in New Jersey, where, at Hanover, Arent Schuyler, a Hollander, had found a vein of copper ore in 1719. It is said that his Negro servant picked up a piece of native copper and brought it to him as a curiosity. Some hammers and other tools found in an old opening in this vein indicated that it had been worked previously by the early Dutch settlers.* The ore proved rich and profitable; it was carried to the Hudson and shipped in barrels to Bristol, in England, where it sold for £40 per ton. We are told that it yielded 80 per cent of copper, which suggests that the mineral was native copper. In 1731 the output was 1386 tons; but no attempt was made at smelting, because the colonists were not allowed to smelt ore and refine copper.†

In 1750 Elias Boudenot leased some land near New Brunswick, also in New Jersey, on which several masses of copper, weighing from five to thirty pounds, had been turned up by the plough. A pit was dug, and at 15 feet the miners found several thin sheets of copper, together with sundry large lumps, all "between the rocks". A stamp-mill was erected, and much excellent copper was sent to England. Again, it is obvious that the mineral was native copper only. At a depth of 50 feet, solid ore, meaning sulphide mineral, was cut, but the cost of labor proved excessive and the mine had to be abandoned. At Somerville also some native copper was found, together with other copper minerals. On Van Horne's mountain, just before the Revolution, two skilful Germans built a furnace and reduced the ore collected from the surface by the settlers in the locality. Two masses of virgin copper, weighing 1900 pounds, were found in 1754. The smelting-works were

* Bishop, *op. cit.*, Vol. I, p. 546. Also J. D. Whitney, 'The Metallic Wealth of the United States', p. xxiii; 1854.

† Caroline C. Newton, 'Once upon a Time in Connecticut', p. 103; 1916.

destroyed during the Civil War. These records of the occurrence and use of native copper are extremely interesting, because they indicate that there were sources of such metal for the use of the aborigines outside the Lake Superior region, to which most of the pre-Columbian copper of the Indians is usually ascribed.

Copper was discovered in Orange county, Vermont, in 1820, and was afterward smelted at Vershire, by a group of residents known as the Farmers' Company. In 1853 the mine was purchased by sundry persons in New York who organized the Vermont Copper Mining Company and operated "under the direction of a skilled Cornish miner".* We are told that this and other mines in Vermont were the principal American source of copper during the eighteenth century, until operations were started in the Lake Superior region.

The first discovery of iron ore in the United States was made by Ralph Lane and Thomas Heriot, who commanded an expedition sent by Sir Walter Raleigh to North Carolina in 1585. When seeking for gold on the island of Roanoke, they found iron ore. Heriot, the historian of this settlement, says: "I know nothing to the contrary but that it [the iron ore] may be allowed for a good merchantable commodity, considering there the small charge for the labour and finding of men, the infinite store of wood, the want of wood and dearness thereof in England, and the necessity of ballasting ships".† He interjects a reference to the fact that the destruction of the forests for the purpose of making charcoal to be used as fuel in the iron-furnaces had already become a burning question in the Old Country. The colonial pioneers had to begin mining in order to obtain iron ore from which to extract the wrought metal needed by their blacksmiths for making tools, and the nails so necessary for house construction. Thus the first mining industry of the people of the United States was started. However, it was not until 1608 that 17 tons of iron

* Rowland E. Robinson, 'Vermont', p. 360; 1892.

† John Pinkerton, 'Voyages and Travels', Vol. XII, p. 594; 1812.

was smelted at Bristol, in England, from 35 tons of ore shipped by the Virginians at Jamestown. From this "iron oare", said Sir Thomas Gates in 1610, they could make as good iron as any in the world.

In 1619 the London Company sent to Virginia a large number of emigrants, among whom were 153 persons said to be skilled in the manufacture of iron. The intention was to establish three iron-works in the colony, the first of these being on Falling creek, a branch of the James river, not far from Jamestown itself and only 32 miles from the sea. This plant started in 1620. Three of the master-workmen died, whereupon, in 1621, a reinforcement of 20 experienced hands was sent from England under the leadership of John Berkeley; but these well-meant efforts soon came to a tragic end, for in 1622 the Indians attacked the iron-works and massacred 347 persons, including Berkeley.* The plant was completely destroyed. No other iron-works were started in the American colonies for many years thereafter.

The scarcity of tools and hardware prompted renewed efforts to manufacture iron in the colonies; in 1643 John Winthrop, Jr., the son of the Governor of Massachusetts, organized a company known as the Undertakers for the Iron-works. The sum of £1000 was raised for the enterprise, but it lagged. The first plant was not erected until 1646 at Lynn, near a group of small lakes of Glacial origin in which bog ore was found. This mineral was easy to obtain and was easy to smelt; it was fused in the furnace with a calcareous flux in the form of sea-shells. Charcoal, of course, was the fuel. The younger Winthrop, who became Governor of Connecticut in 1657, started iron-works at New Haven in 1662. The operations started by Winthrop were continued intermittently, and at a small profit, on account of litigation and other troubles. The alleged destruction of the forests, to obtain the requisite charcoal, made the iron-founders as unpopular in New England as they

* Bishop, *op. cit.*, Vol. I, p. 469.

were in Old England, where the devastation of the oak woods was deemed a national calamity. This prejudice, on both sides of the Atlantic, hindered the development of the iron industry most seriously until the use of coal provided a new, and a better, fuel for the metallurgist. The colonial iron-furnaces, like those of contemporary England, were 'bloomeries', that is to say, they yielded blooms, or lumps, of wrought-iron, which were hammered on forges near the forests from which the charcoal was obtained. It is recorded that New England had 6 furnaces, 19 forges, and a nail factory in 1731.

The first cast-iron was made in 1727, in Pennsylvania;* this is remarkable, because the art of casting iron was known in Europe—in Belgium and England—more than two centuries earlier. The first castings made in sand in America are credited to Joseph Mallinson, of Dusburo, who started the practice in 1739 and received a grant of 200 acres of unimproved land in recognition of his useful invention. It was the custom at that time to close down the furnaces during the summer, on account of a shortage of the water-power required to force the blast. The steam-engine was not introduced for this purpose until 1800, although it had been in use in the British iron-works for half a century.

The smelting of iron from bog ore at Middleboro, in Massachusetts, was prompted by finding such deposits in numerous small ponds in the township. "The ore was dragged from the water by an instrument similar to an oyster dredge, at the rate of about two tons per diem for each man, which quantity gradually diminished to half a ton a day."† A richer deposit of the ferric peroxide was discovered in 1747, and a good supply was forthcoming, so that rolling-mills, employed chiefly for making nail-rods, were started at Middleboro. This enterprise was soon checked by an act of Parliament that was meant to encourage the exportation of iron ore from the colonies to

* James M. Swank, 'History of the Manufacture of Iron', p. 169; 1892.
† Bishop, *op. cit.*, p. 490.

England, and to discourage iron manufacture in America. This arbitrary exercise of legislative authority was much resented in Massachusetts, and contributed to the irritation that culminated in the Revolution.

Although the numerous small deposits of bog ore were the principal resources of the early iron manufacturers of New England, they soon yielded in importance to the hematite and magnetite ores found in the western counties of Massachusetts, notably in the Berkshire hills, and also in the adjacent parts of New Hampshire, Vermont, and New York. A furnace to smelt such ores was erected at Hardwick, on the river Ware, in 1773 by Joseph Washburne, who received a grant of a limestone tract to supply him with the necessary flux.

The first iron manufactured in Pennsylvania was produced at a bloomery at Coventry, in Chester county, in 1718. Ten years later, four furnaces were at work. In 1776 the furnaces at Warwick and Reading were engaged in casting cannon for the State. These furnaces were blown by long wooden bellows, propelled by water-wheels, and when in blast they produced from 25 to 30 tons of iron weekly. The price of pig-iron in 1789 was £6½ Pennsylvania money, equivalent to $17·33, per ton. By the time George Washington became President, the making of iron on a small scale was established in every one of the thirteen States of the Union.

The immigration into the western wilderness was followed in 1791 by the establishment of iron-works in the Mississippi valley: at Bourbon, in Kentucky. This furnace was so close to the frontier that the workmen had to be guarded from attack by the Indians. The pots and kettles, and blacksmith iron also, fabricated at this metallurgic outpost had a wide market throughout the pioneer settlements.* In 1810 the Secretary of the Treasury stated that the annual value of iron and its manufactures in the United States was about $13,000,000. The iron imported was valued at $4,000,000 per annum.

* J. Russell Smith, 'The Story of Iron and Steel', p. 36; 1908.

There were 530 forges and bloomeries in the country. To encourage the domestic industry, the first tariff on iron was levied in 1816.

The enormous deposits of iron ore that have given the United States the material for a colossal steel industry were not discovered and developed until a comparatively recent date. The first mention of iron ore in the Lake Superior region is to be found in a letter written in 1840 by Douglass Houghton, the first State Geologist of Michigan, but he did not consider the deposits of economic value because his investigations were restricted mainly to the shore of Lake Superior, and to places therefore where no considerable outcrops were to be seen. The real discovery is to be credited to William A. Burt, who was in charge of a surveying party in 1844, when he noticed the erratic behavior of his compass needle, which gave readings 87 degrees from the normal.* Ascribing this effect to the nearness of iron ore, Burt and his companions searched for outcrops and soon found several, from which they broke samples. A map made at that time shows the name Iron Hills. The first iron deposit to be discovered and to be exploited became the Jackson mine, which was described, in a letter of November 10, 1845, as "a mountain of solid iron ore, 150 feet high". The ore was said to look "as bright as a bar of iron just broken". This discovery was made on July 23, 1845, by S. T. Carr, who was guided to the locality by an Indian chief named Manjekijik. His name deserves to be honored, for it was he that led the way to a momentous event. In reward for his service, the Indian was given, by official letter, a share in the location, but this promise was never fulfilled, and Manjekijik died in abject poverty, although the Jackson Mining Company, afterward the Jackson Iron Company, became a highly profitable enterprise. The land was bought from the Government for $2·50 per acre. Eleven persons, most of whom lived at Jackson, in Michigan, organ-

* T. B. Brooks, 'Geological Survey of Michigan', Vol. I, p. 13; 1873.

ized the company and procured permits from the War Department to locate one square mile apiece on the south shore of Lake Superior.

The first attempts to smelt the ore were failures, but in August 1846 a man named Olds succeeded in making a good bar of iron in a blacksmith's fire, this being the first iron produced from Lake Superior ore. A forge was constructed on the Carp river, three miles east of the mine, and on February 10, 1848, A. N. Barney smelted the first bloom from which merchantable iron was made. This iron, from specular ore, was used in the building of the steamboat 'Ocean'. The iron was smelted as a bloom, which was hammered into bars, four inches square and two feet long. In 1850 five tons of the Jackson ore was taken to the iron-works at Newcastle, Pennsylvania, where it was made into bar-iron by A. L. Crawford. Here we have the first link between the coal of Pennsylvania and the iron of Lake Superior—an event of deep significance. The first blast-furnace to treat Michigan ore was built near the Jackson mine by C. T. Harvey for the Pioneer Company in 1858. The Civil War created a demand for iron and thereby stimulated the young mining industry of this Marquette region. In 1929 the Lake Superior region yielded 65,443,546 tons of ore averaging 51·18 per cent of iron.

America continued to use charcoal in the iron-furnace for 90 years after England had discarded this primitive fuel.* The Americans of that day were not a manufacturing people, they made iron for the blacksmith; their production of iron was a small and local industry. After the United States achieved independence the immigration of skilled iron-workers from England, despite stringent emigration laws, brought men that were well versed in the art. In an advertisement appearing in the Pittsburgh 'Mercury' of May 27, 1813, one of the newcomers from overseas offers to instruct blast-furnace managers in the method of converting coal into coke. In

* B. F. French, 'History of the Rise and Progress of the Iron Trade of the United States'; 1858.

1817 at Plumsock, in Pennsylvania, a rolling-mill was started by Isaac Meason, who used coke in his refinery.* This mill was built by an English immigrant, who built another blast-furnace near Parker's Landing in 1819; and there also coke was used. But these attempts to use the new fuel were abandoned, because the blast available was too feeble. Other similar efforts proved abortive. In 1825 William Strickland was sent to England, to study the subject, by a Society for the Promotion of Internal Improvement in the Commonwealth of Pennsylvania. Strickland, in due course, forwarded his report, but even the information made available by him proved insufficient, probably because the right kind of coal was not obtainable. The offer, in 1835, of a gold medal, by the Franklin Institute, for the making of not less than 20 tons of iron from ore by aid of "no other fuel than bituminous coal or coke" suggests that theretofore the best results had been obtained with other fuels or by mixing coal and coke with charcoal. It has been claimed that coke was made and used at the Allegheny furnace in Blair county, Pennsylvania, in 1811, but it is not clear that coke was used alone. However, in 1835, as if in consequence of the promised award, good gray forge-iron was made by William Fernstone with coke from Broad Top coal, and to him therefore apparently we must accord the honor of being the first successful maker of coke-iron, at a date nearly a century after Abraham Darby had first used coke successfully at Colebrookdale in England.

The development of ample coal resources was, of course, essential to the existence of large metallurgic enterprises in the United States. It is doubtful whether the American aborigines knew how to use coal, although one of the Jesuit missionaries has recorded the fact that he saw the Algonquins "making fire with coal from the earth" as early as 1660. The coal of Illinois and Mississippi wins mention in some of the early chronicles of the seventeenth century. The exploring

* Franklin Ellis, 'The History of Fayette County, Pennsylvania', p. 242; 1882.

friar, Louis Hennepin, states that the Indians on the Illinois river were digging coal in 1679.* A mine of bituminous coal was started in 1750 near Richmond, in Virginia, for the use of local blacksmiths. Maps dated 1770 and 1777 mark the sites of coal mines in Ohio; a flatboat loaded with coal dug in Jackson county was taken to New Orleans in 1810. The first discovery of anthracite in Pennsylvania was made by a hunter, Philip Ginter, who, in 1790, stumbled upon a piece of black stone that he suspected to be coal. In 1812 George Shoemaker of Pottsville hauled nine wagonloads of anthracite to Philadelphia, but he could sell only two, and gave away the seven others. He was regarded as an impostor for attempting to sell stones as coal, and found it expedient to get out of town promptly to escape arrest. Several chroniclers tell the story of the subsequent discovery of how to burn anthracite. One of the loads of coal sold by Colonel Shoemaker was purchased for a wire-works on the Schuylkill river. "A whole night", says Nicolls, "was spent in the effort to make the coal burn, when the hands in despair quit their work, but left the door of the furnace open. Fortunately, one of the workmen forgot his jacket, and returning found everything red hot." The anthracite, to burn properly, needed a strong draught. At the beginning of the nineteenth century the coal mines of Virginia constituted an important local industry, but this business was interrupted by the War of 1812, and in the interval the anthracite mines of Pennsylvania underwent preliminary development. The total output of coal in 1828 was only 95,980 tons of anthracite and 100,480 tons of bituminous coal, "not enough now", as Bain says, "to heat the government buildings at Washington".† Coking coal was discovered in 1842, and its great usefulness for the smelting of iron ore was proved in 1859 at Pittsburgh.

* Louis Hennepin, 'A New Discovery of a Vast Country in America', translated by Reuben Thwaites from the French edition of 1697, Vol. I, p. 152; 1903.

† H. Foster Bain, 'A Century of Industrial Progress', p. 94; 1928.

Then from England came the locomotive and the beginning of an era of railroad building that has gridironed the American continent with lines of steel over which the stream of commerce flowed unchecked by any inter-State duties. The first American railroad was opened to traffic in 1830. The railway mileage increased from 4,026 in 1842 to 93,262 in 1880 and to 258,238 in 1924. Most of this was constructed by aid of English capital. In 1925 the exports of the United States were \$4,909,848,000, the excess over imports being \$683,258,000. The average daily production of coal per man employed in the mining of bituminous coal in the United States increased

PRODUCTION OF COAL AND STEEL IN 1913

Country	Coal, tons	Steel, tons
United Kingdom	292,202,000	7,543,000
United States	562,595,000	31,823,000
Germany	278,627,000	19,292,000
France	42,671,000	4,419,000

from 2·56 short tons in 1891 to 4·73 tons in 1928, and it is significant that during this period the proportion of coal mined by machine increased from 5 per cent in 1891 to 74 per cent in 1923; nevertheless, owing to higher wages, the cost per ton increased from \$1·12 per ton in 1916 to \$2·86 per ton in 1922. Meanwhile the industrial development of the country is expressed eloquently by the per capita consumption of coal, which increased from 0·03 ton in 1825–1834 to 5·37 tons in 1915–1924. From 1886 to 1913 the production of coal increased in England from 158 to 287 million long tons; during the same period the American output increased from 102 to 509 million long tons. While England's production increased 80 per cent, that of the United States increased 400 per cent. During the same period the production of iron in England increased from 7 to 10 million tons; in the United States, from 5¾ to 31 millions; and in Germany, from 3½ to 19½ millions. In 1929 the American output of coal was 552,465,000 tons.

The outputs of coal and steel in 1913 give a measure of the industrial preparedness of the four Great Powers to meet the exhaustive test of a world war. See figures given on page 16. Industrially Germany could face the combined strength of England and France, but when America entered the war she was doomed to defeat. In the future, as in the past, industrial vigor will be the principal factor in deciding the contests between peoples; let us hope, sincerely and insistently, that our strength will be used only to prevent the obscene insanity of war, which is the complete negation of civilization.

CHAPTER II

THE GOLD DISCOVERIES

When Ponce de León landed in Florida in 1573 he was told of an Indian chief that possessed much gold. In 1576 Diego Meruelo obtained some of it from the Indians, and in 1579 Álvarez de Pineda reported that the natives wore ornaments of gold, which they obtained from the rivers. These statements all refer to the southern Appalachian region. The name is recorded in 1527; when Pamphilo Narváez landed at Tampa he heard that there was much gold to be obtained in a region named Apalache.* In 1564 René Laudonnière describes the methods used by the natives to win gold in the Apalatcy mountains.† However, no serious mining operations were undertaken until long afterward; the mining of gold in the Southern States may be said to have had its beginning when a nugget was found at the Reed mine, in North Carolina, in 1799. This nugget, which was of "the size of a small smoothing iron", was kept for several years before the finder learned what it was, but later more lumps, one weighing 28 pounds, were found in the same locality, and eager digging ensued.‡ Thomas Jefferson, in his 'Notes on Virginia', mentions the finding of a quartz specimen, not a nugget as is generally stated, that contained 17 pennyweights of gold; this was found on the Rappahannock river in 1782.§

* 'The Narrative of Alvar Nuñez Cabeça de Vaca', translated by Buckingham Smith, p. 18; 1851.

† Richard Hakluyt, 'The Principal Navigations, Voyages, and Discoveries', p. 352; 1600.

‡ George F. Becker, U. S. Geol. Survey, *Annual Report*, Vol. XVI, part 3, p. 253; 1894.

§ Thomas Jefferson, 'Notes on the State of Virginia', p. 36; 1825.

The Mint reports show that gold was produced in North Carolina in 1793; up to 1828 this State yielded all the gold that was produced in the United States, the total amount, however, being only $110,000.* Virginia's name appears in the Mint report for 1829. In that year there was a real rush to Georgia, and a few years later a gold discovery was made in Alabama. In 1833 and 1834 the gold collected in Virginia, the Carolinas, and Georgia was worth about a millon dollars per annum. Three mints were established in 1838, at Charlotte, North Carolina, at Dahlonega, Georgia, and at New Orleans, Louisiana. The last mentioned did not function until the Californian gold began to go thither.

The early mining operations in the South were all based upon placer deposits and soft outcrops. The Haile mine, in South Carolina, was started with placer and open-cut workings in 1829, no underground mining being undertaken until 1880. In later years, when in 1890, the Haile mine was revived, it became an important centre of metallurgical progress under the progressive management of Adolph Thies. From 1804 to 1866 the Appalachian goldfield, extending into five States, yielded $19,375,890. Concerning the gold-mining industry of the South it may be said, retrospectively, that it was relatively unimportant, but it played a useful part in preparing American miners for the bigger developments in the West. The maximum output was between 1840 and 1849, after which the Southern diggings were completely eclipsed by those discovered in California.

E. T. McCarthy, a distinguished British mining engineer, in a book of reminiscences, kindly and humorous, has told of his experience at a gold mine in North Carolina 50 years ago.† In the office were files of vouchers from slave-owners in the days before the Civil War, these receipts covering the loan of

* H. B. C. Nitze and H. A. J. Wilkins, *Trans.* Amer. Inst. Min. and Met. Eng., Vol. XXV, p. 679; 1896.

† E. T. McCarthy, 'Incidents in the Life of a Mining Engineer', p. 11; 1918.

slaves for work in the mine. The ore was of low grade, but the total expense was rarely more than a dollar per ton, so that the manager was able to make a precarious profit. Labor was cheap, the negroes being paid half a dollar per shift. Oak wood cost a dollar per cord, and pine only 75 cents. But it was a small mine, such as did not warrant expansive operations; and this was true of most of the Southern mines.

The discovery of gold in California by Marshall in 1848 was the most portentous event* in the history of modern mining, because it gave an immediate stimulus to worldwide migration, it induced an enormous expansion of international trade, and it caused scientific industry to invade the waste places of the earth. It is true, the occurrence of gold in California was known previously, but the finding of gold and the knowledge that it could be found were by themselves of little moment; it was the production of gold on an industrial scale, and lavishly, that rendered Marshall's fortuitous discovery so momentous.

In a book entitled 'A System of Mineralogy', by Robert Jameson, published at Edinburgh in 1816, it is written: "On the coast of California, there is a plain fourteen leagues in extent, covered with alluvial deposits, in which lumps of gold are dispersed". This is quoted, not quite correctly, by Humboldt. The plain mentioned by the Scottish mineralogist is difficult to identify, but it may be the one from which the Mexicans obtained gold before the American invasion. In 1842 Manuel Castañares, the deputy from California in the Mexican Congress, went to California for the purpose of investigating industrial conditions; he remained there two years, and in his report, dated March 2, 1844, at Mexico City, he states: "The gold placer discovered in the middle of last year has attracted the greatest attention, for it extends nearly thirty leagues; the purity of the metal is shown by the assay

* T. A. Rickard, 'The Discovery of Gold in California', University of California, *Chronicle*, April, 1928. Also 'The Later Argonauts', *Trans.* Inst. Min. and Met., London, Vol. XXXVI, pp. 14–37; 1927.

certificate made by the mint at this capital, the original of which I send herewith". On September 1, of the same year, he writes: "The mining interest in California is of greatest importance, and I have the satisfaction of assuring you that it forms one of the most valuable resources of the department [of Upper and Lower California] . . . On my departure from that town [Los Angeles] in December, 1843, there were in circulation about 2000 ounces of gold, which have been extracted from the above mentioned placer, the greatest part of it destined to go to the United States".* The goldfield to which he refers was near the Santa Feliciana canyon, 40 miles northwest of Los Angeles; the discoverer was Francisco López, a herdsman, who (on March 9, 1842) found the gold while digging wild onions with a knife. This discovery was known to those then living in that part of California.† The diggings were worked on a small scale, but profitably, until 1854; their existence was known also to American officials, for, on May 2, 1846, the U. S. Consul at Monterey, Thomas A. Larkin, wrote to Commander Montgomery as follows: "At San Fernando, near San Pedro, by washing the sand in a plate any person can obtain from one to five dollars per day of gold that brings seventeen dollars per ounce in Boston. The gold has been gathered for two or three years, though but few have the patience to look for it". This evidently is the placer mentioned by Castañares.

Another early discovery that has been authenticated is credited to Jedediah S. Smith. In 1825 he came to California at the head of a party of trappers in the employ of the American Fur Company. Starting from Wyoming, the party reached the Humboldt river, in Nevada;‡ from there Smith and two others crossed the Sierra Nevada at the head of

* Colección de documentos relativos al departamento de California', Mexico; 1845.

† Charles J. Prudhomme, *Historical Society of Southern California*, Vol. XII, p. 18; 1922.

‡ W. A. Chalfant, 'The Story of Inyo', p. 43; 1922.

the Truckee river, and then descended into the valley of the Sacramento, to proceed on their way to San Diego. Coming back, Smith crossed the mountains at Walker's pass and skirted the eastern slope, discovering Mono lake, where he found gold "in quantities, and brought much of it with him to the encampment on the Green river",* to which he returned safely. On making a second journey, in 1826, with the purpose of prospecting again, he and most of his companions were killed by Indians. This disaster caused the American Fur Company to desist from further exploration. No more was heard about the gold discovery.

Why were such facts ignored? It may be that the American Government was already anticipating a change of national ownership of the region in the near future. The Mexicans were disinclined to encourage mining in California; the *hacendados* deprecated any move that would take laborers from their fields and gardens; the Franciscan *padres* were afraid that a rush to the goldfield might bring a horde of new settlers, *Americanos*, who would dispute their dominance over the Indians. Both were correct in their anticipations, as the sequel proved.

Why did the earlier Spaniards miss the treasures of California? They thought to gather the gold easily after it had been wrested from the earth by the laborious effort of the natives, they dreamed of tearing it from the glittering domes of the fabulous Seven Cities of Cibola, they expected that the Indian temples would be stored with images studded with lumps of gleaming metal. The *conquistadores* failed because they sought for gold with the sword and spear, instead of the pick and shovel.

Thus the eventful discovery was postponed to later days, when a carpenter, ignorant of mining, happened to stumble upon a find of gold and accidentally won a name in history. In January, 1848, James W. Marshall was building a saw-mill

* J. Ross Browne, 'Reports upon the Mineral Resources of the United States', p. 305; 1867.

at Coloma on the south fork of the American river, 40 miles northeast of Sacramento, which is now the capital of California. Marshall was a wheelwright from New Jersey, and he was building the saw-mill, which was to be driven by water-power, in partnership with John A. Sutter, a Swiss merchant adventurer whose *hacienda* was at New Helvetia, now part of Sacramento, where he had a tannery, a ranch, and a trading-post. When the mill was nearly completed, Marshall noticed that the tail-race was not deep enough, so, in the afternoon of January 23, he opened the water-gate for the purpose of permitting the full stream to run during the night. In the morning, while the mill-hands were at breakfast, he shut off the water and sauntered down the bed of the tail-race to see if it had been deepened sufficiently by the scouring action of the current. While doing so, he detected several bright bits of yellow mineral on the flat stones; he guessed that the mineral must be either pyrite or gold, and he knew that one of these was brittle whereas the other was malleable, whereupon he picked up the largest flake, which was about the size of a melon seed, and bit it; then he pounded it on a rock, proving thereby that it was soft.* Surmising therefore that the metal was gold, he gathered several of the flakes, put them in the crown of his hat, and exhibited them to a group of mill-hands, consisting of five white men and three Indians. As he approached them, he exclaimed: "Boys, by God, I believe I have found a gold mine". One of the Indians, who had seen gold in southern California, murmured "*Oro*". When a man named Smith produced a five-dollar gold coin and compared it with the flakes, those present agreed that, although the color was slightly different, the metal was the same. Then Marshall is said to have gone to the cook, Jennie Wimmer, from whom he obtained some vinegar to make a test of solubility, but this part of the story is doubtful. Another statement, better

* Philip B. Bekeart, *Quarterly Journal*, Society of California Pioneers, Vol. I, No. 3; 1924.

corroborated, is that Mrs. Wimmer happened to be making soap, so Marshall asked her to boil the largest flake in strong lye, and in the morning, when it was cut out of the soap that lay on the bottom of the kettle, it showed no discoloration. Finally, Marshall took it to the blacksmith and told him to beat it thin on his anvil, again proving how malleable it was. Meanwhile some of the mill-hands went to the tail-race and gathered several more flakes of gold.

Upon the monument erected in 1890 at Coloma by the State of California to the memory of Marshall, the date of the discovery is given as January 19 and the gold he found is described as a "nugget". Both of these statements are incorrect. At that time many Spanish words were in use among the Americans in California. Marshall used the word *chispa* to designate the gold that he had found. In this context *chispa* is best translated as a bright speck or spangle. The first and largest spangle that Marshall picked up on January 24, 1848, was sent by Sutter to the Smithsonian Institution, at Washington, where it is described as follows: "Under the microscope it shows numerous white particles imbedded in it, which are apparently of quartz. Two small thin films of quartz are still attached to it, as found. There are further many minute black points of no appreciable thickness, which are evidently iron or manganese oxide". The particles of quartz became imbedded in the soft gold when Marshall pounded the flake on the granite, and the black spots were acquired when the gold was hammered on the blacksmith's anvil. The event was recorded in the diary of Henry W. Bigler, a Mormon worker at the mill; under date of January 24, he wrote, on a page that has been preserved among the archives of the Society of California Pioneers,* as follows: "This day some kind of mettle was found in the tail race that looks like goald"; and to this subsequently he added the statement: "first discovered by James Martial, the boss of the mill".

* John S. Hittell, 'Marshall's Gold Discovery', Society of California Pioneers, 1893.

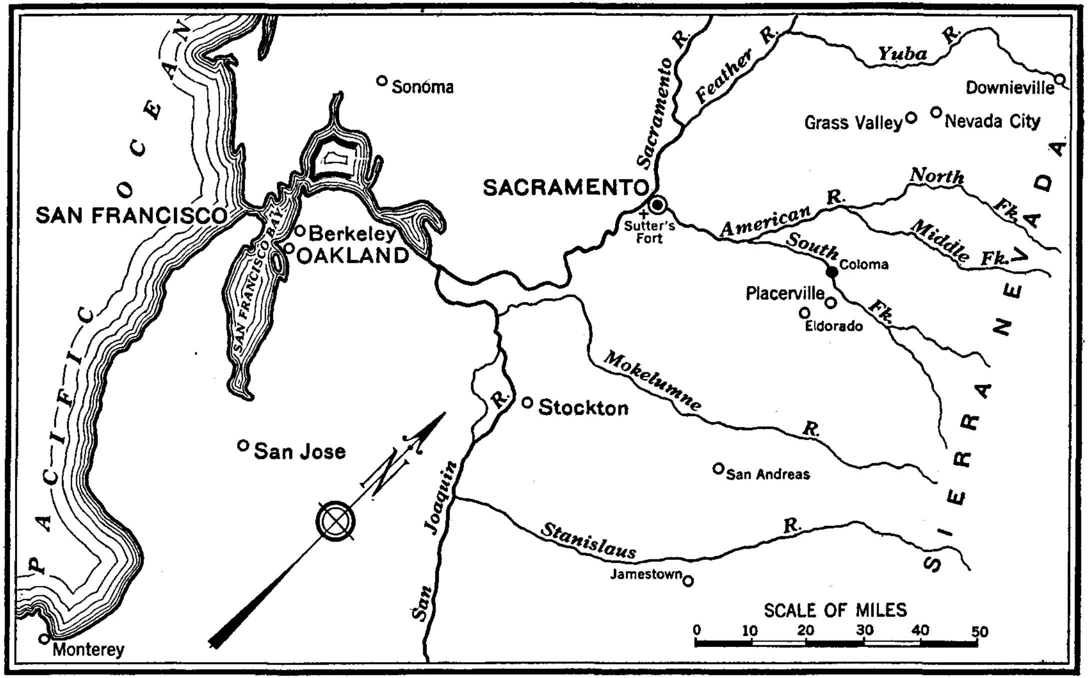


FIG. 1.—The Californian goldfields.

On January 28 Marshall went to Sutter's *hacienda* to report the discovery. Upon entering the office at New Helvetia he locked the door and drew forth a rag in which the yellow flakes, altogether about three pennyweights, were wrapped. Sutter tested the metal with some nitric acid that he happened to have among his apothecary stores; he then pulled down a copy of an old encyclopaedia and read the article on 'Gold'; then, he weighed the flakes when immersed in water; he compared their gravity with that of some silver coins; whereupon he pronounced the metal to be 22-carat gold; and his decision, spoken in that frontier store at the foot of the Sierra Nevada went forth to all the world, at first only the whisper of rumor, but soon a shout of exultation, summoning the adventurous of every land to California.

The next day Sutter followed Marshall on horseback to Coloma and with him examined the tail-race, along which they picked up some more bits of gold. After looking around for a day or two, Sutter returned to his *hacienda,* but before leaving he asked the mill-hands to say nothing about the discovery: to keep it secret for six weeks; he did this because he feared that any excitement might cause his workmen on the ranch to leave him.* Curious to relate, the men at Coloma did not appreciate the significance of the discovery and most of them left California shortly afterward. One of them, however, carried the news to San Francisco; this was Charles Bennett, a carpenter, who exhibited some of the gold flakes and told the story of discovery. Among others to whom he gave the information was Isaac Humphrey, who, having been a miner in Georgia, understood what it meant and promptly accompanied Bennett when he returned to the mill a few days afterward, arriving there on March 7. The mill-hands were still at their regular work, no gold-digging having as yet been started, whereupon Humphrey did a little panning on his own account and then constructed a rocker such as he had used in Georgia. With this machine he began to wash the gravel near

* Theodore H. Hittell, 'History of California', Vol. II, p. 686; 1898.

the mill and obtained two or three ounces of gold per day.* This, when it became known, put an end, of course, to work at the saw-mill. All the men betook themselves to gold-washing.

Neither Marshall nor Sutter profited by the discovery. The laborers left the saw-mill; the men on the ranch decamped to the diggings; the tannery was ruined; the Indians even refused to harvest Sutter's crops; the miners stole his cattle and rode off on his horses. Prosperous before, he was beggared by the gold-seekers and by the disorganization that ensued. Nothing remained for him but to join the others in the search for gold; he started on a prospecting expedition, but it failed, and, in the end, he had to be pensioned by the State. Marshall, a man of morose temper and defective intelligence, had no luck whatever, and soon became indigent; eventually he also received financial aid from the State, but he died a poor and utterly frustrated man. In 1848 California yielded $10,000,000 in gold.

At that time California had but lately been added to the United States at the close of a war with Mexico; indeed, it is interesting to note that the treaty of Guadalupe Hidalgo, which marked the end of hostilities, was signed on February 2, 1848, whereas the discovery of gold by Marshall was made on January 24; in other words, California was ceded by Mexico to the United States nine days *after* the momentous discovery, which, at that date, was not known to either government. By the treaty with Mexico the United States annexed California, New Mexico, Arizona, Nevada, Utah, together with portions of Colorado and Wyoming, paying only $15,000,000 for these magnificent domains. In 1849, a year later, California produced gold equivalent to three times the payment made under the terms of the treaty.

The first public notice of the discovery of gold appeared in 'The Californian', a newspaper issued in San Francisco, under date of March 15, 1848:

* Henry Degroot, *Mining and Scientific Press*, Vol. XLVII, p. 320; 1883.

"Gold Mine Found.—In the newly made race-way of the saw-mill recently erected by Captain Sutter, on the American fork, gold has been found in considerable quantities. One person brought thirty dollars worth to New Helvetia, gathered there in a short time. California, no doubt, is rich in mineral wealth; great chances here for scientific capitalists. Gold has been found in almost every part of the country."

This indicates the current belief that gold existed in the region. It is noteworthy that this press announcement of the momentous discovery was made nearly two months after the event.

On the twenty-ninth of May 'The Californian', when announcing that its publication would be suspended, said:

"The whole country, from San Francisco to Los Angeles, and from the seashore to the base of the Sierra Nevada, resounds with the sordid cry of *gold! gold! gold!* While the field is left half planted, the house half built, and everything neglected but the manufacture of picks and shovels, and the means of transportation to the spot where one man obtained one hundred and twenty-eight dollars worth of the real stuff in one day's washing; and the average for all concerned is twenty dollars per diem."*

On the same date the American *alcalde* at Monterey, named Walter Colton, refers in his diary to the excitement caused by news that gold had been discovered, and on June 20 he records the fact that the man whom he had sent to the diggings had returned with specimens of gold, which had caused an immediate stampede of the people at Monterey.† Such also was the effect of the news in distant places. An excited migration ensued across the plains, over the Panama isthmus, and around Cape Horn; the young and energetic of many lands hurried to the Eldorado that promised to fulfil the dreams of Raleigh's day. Most of the men that rushed to California had never

* J. Ross Browne, 'Reports upon the Mineral Resources of the United States', p. 15; 1867.

† Walter Colton, 'Three Years in California', p. 246; 1850.

seen a mine, but that did not matter; they came to do the work of mining and with the washing of the first panful of gold-bearing gravel they became industrial sappers, the brothers of the pick and gad. They had the machinery most used in mining: human muscle; they had the science most approved in that ancient art: organized common sense; they achieved the basic purpose of mining: to exploit mineral at a profit. As Jason and his comrades found the Golden Fleece on the banks of the Colchis, so these later Argonauts found the splendid treasure that had been stored for them during geologic ages in the beds of the Yuba, Shasta, and American rivers; but, instead of the sheep's fleece, they used blankets for catching the fine gold. The daily winning averaged about an ounce of gold per man. "It was no uncommon event for a man alone to take out five hundred dollars in a day, or for two or three, if working together, to divide the dust at the end of the week by measuring it with tin cups. But we were never satisfied", says one of the pioneers.

Their apparatus was simple.* At first a shovel and any kind of shallow vessel sufficed, such as a frying-pan, the gravel being shoveled into it and then washed with a circular shaking movement, on the edge of a stream, so that the light and barren sediment was carried away, leaving the heavy sand behind; and this again was washed further, the big lumps being picked out by hand, until a glittering string, or tail, of golden particles remained. If the gold was coarse, in nugget form, the operation did not have to be finished before disclosing the precious metal. The handle of the frying-pan was soon removed, and the prospector's pan became a circular sheet-iron or tin-plate dish with sloping sides, usually 15 to 16 inches in diameter, 10 to 11 inches across the bottom, and from 3 to 4 inches deep. The use of it by the miner was essentially a method of concentration, resembling the long-continued action of the water in the stream, by means of which the detritus of the hillside had been sorted and accumulated in particular

* James J. Ayres, 'Gold and Sunshine', p. 43; 1922.

places, to be hidden there until the digger uncovered it. Later he devised a simple machine for doing his work more expeditiously; he made a wooden box, about three feet long, sloping gently and mounted on rockers, like a baby's cradle. Above the upper end he placed a smaller box, bottomed with wire-screen or sheet-iron in which holes had been punched, this device serving as both a hopper and a sieve, to exclude the stones and coarse gravel, which were discharged by lifting the box. To the side of this 'cradle' or 'rocker', as it was variously named, a handle was fixed, so that the digger could move it to and fro with one hand while with the other he poured water over the gravel in the hopper by means of some sort of dipper or can nailed to a piece of wood. Whatever went through the bottom of the hopper fell to the floor of the cradle, the rocking of which expedited the separation of the barren sediment, which was washed away, leaving the gold and iron sand behind. This contrivance served the digger's purpose fairly well, but he ascertained shortly that he was losing the finer particles of gold, whereupon he constructed a machine somewhat more elaborate. He lengthened the cradle until it became a trough or launder 8 to 10 feet long, and to the bottom at intervals he nailed transverse cleats, or riffles, to arrest the smaller particles of gold as they slid along with the heavier sediment, while the worthless dirt was washed away by the water that was poured into the hopper. This machine became known as the 'long Tom'. Finally the elongated cradle, thus developed, was replaced by a series of sluice-boxes, or sectional launders, in which the gold-bearing sediment was disintegrated and washed by a running stream of water while men on both sides stirred the gravel on the bottom and lifted the large stones out of the run-way by means of shovels or forks. In addition to riffles, the digger used blankets, such as those in which he slept, the woolly fibre serving to catch the dust of gold. At a later date the miner summoned to his aid a chemical agent; he placed quicksilver in his riffles, so that the gold was amalgamated, or alloyed, with another heavy

metal, which arrested the particles of gold and prevented the minute flakes from running away. The amalgam was collected, put into a buckskin bag, squeezed by hand, so as to discharge the excess of quicksilver, the residue being then exposed to heat, in a retort, whereby the highly volatile mercury was expelled, leaving the gold free.

Most of the gold lay on the bedrock, to which natural bottom it had settled through the gravel on account of its gravity, this descent being aided, during the geologic aeon, by such constant vibration of the ground as is exhibited in its major form by earthquakes. Sometimes a layer of clay was mistaken for the base of the deposit, but in the course of experience, the result of accident and observation, the digger ascertained that the clay might constitute a false bottom, below which, on the true bedrock, more gold was to be found. Usually the precious metal had settled into the cracks and crannies of the rock, and in such places were discovered the pockets from which gold was gathered in handfuls. Rich deposits occurred in what seemed to be the most unlikely places; even high on the hillside the digger found gravel of surprising richness, and apparently the very laws of gravity were flouted by the discovery of the precious metal on bedrocks that had a reverse slope. These were the remains of older stream-bottoms, now mantled with lava, across which the existing river had cut its way.

Each man had his own theory about the distribution of the gold. Most of the diggers dreamed of a mother source, somewhere in the heart of the mountains, from which the gold had been washed into the creeks and gulches near the foot of the range. They recognized the action of water in moving and concentrating the gold, but they failed at first to appreciate the fact that it had been derived by erosion from the quartz veins in the hills near-by. So, eager prospectors climbed the mountains and sought for the inexhaustible origin of all this widely scattered wealth; and even after gold had been discovered in the veins along the lower slopes of the Sierra they

continued to search for the great central vein from which the gold, they thought, had flowed or had been ejected in the old volcanic days; for by this time they were aware of the fact that layers of lava had covered the former surface in places and had buried the ancient river-bottoms as much as fifteen hundred feet. The early placer miners underestimated the productivity of such veins as were proved to contain gold, and assumed that they would be profitable only to a shallow depth. So did their geologic notions swing to and fro.

At first the digger worked singly, but he soon found it more convenient to have a partner, not only for company but because the lone man was economically a misfit. Usually one man shoveled the gravel while the other washed it in the cradle or rocker. As the workings increased in size it became necessary to operate in parties of four or more. Thus larger and more lasting partnerships were formed, and clusters of cabins began to appear among the pines on the hillsides. In the summer of 1848 about five thousand men were at work in the gulches and along the streams of the Sierra Nevada.

By what legal right, it may be asked, did these adventurers, many of them Europeans, exploit the alluvial deposits and remove the gold? The territory of California, recently acquired from Mexico, was under military rule, and the officer in command, Colonel Richard B. Mason, thought it best, as he said, "not to interfere, but to permit all to work freely" on the goldfields. Official opinion is made clear also in the report of his successor, General Persifor F. Smith, who, a year later, stated that the mines were on public lands and belonged to the government of the United States, but he deemed it to be neither the policy of the government nor the wish of the people of the United States to eject the diggers, because of the benefit done "to general trade by the diffusion of the precious metal". As in medieval days, it was found wise to encourage the miner in his production of useful metal. The general in command of the Pacific division remarks in 1849:

"I do not conceive that it would be desirable to have the mines worked for the benefit of the public treasury. To do that would require an army of officers and inferior agents, all with high salaries, and with opportunities and temptations for corruption too strong for ordinary human nature. The whole population would be put in opposition to the government array, and violent collisions would lead even to bloodshed . . . If the Government shall desire revenue enough to pay the expenses of executing the laws passed on the subject, it is the most that should be proposed. The advantage the whole country will derive directly from the opening of the mines, and the indirect advantage to the treasury from augmented commerce, will, in my opinion, more than compensate for any outlay it has made or may make."*

He, evidently, was a sagacious man. The Mexican mining law was no longer operative in California, no law of the United States was applicable to the new diggings, and no State government† had as yet been organized, therefore the diggers were left to their own resources, and they promptly met the needs of the moment by drafting their own regulations. They did this so sensibly that their local rules became the substance of the mining law of the United States as enacted by Congress in 1866.

The right to locate a mining claim, and to hold it against all comers, until abandoned, was generally admitted. This basic idea of mining law had been brought by the adventurers to California from other lands; it was the traditional right of the miner, as much in the seven mine-cities of the Harz as in the stannaries of Devonshire and Cornwall. Title, it was agreed tacitly, was derived from the first locator, and continuity of work sufficed to maintain persistence of ownership. This simple code was established by mutual agreement of the diggers in meeting assembled, and by their willingness jointly

* Report of General in Command of the Pacific Division, October 7, 1849.

† California became a State of the Union on September 9, 1850.

to use force in support of any comrade that might suffer wrong from a trespass on his claim. The size of it, from thirty to a hundred feet square, was established in the same manner, a modification being made in accordance with the character of the deposits, for some of them necessitated a larger area, in proportion to the scope of operations, the amount of the preparatory expenditure, and the number of men needed to conduct the work on a suitable scale. Each man had his say, any man was as good as another, and the rudimentary community accepted the decision of the group as final. Thus was the organization of the mining-camp evolved. Bayard Taylor, a trustworthy observer, who visited the diggings in 1849, says:

"In all the large digging districts which had been worked for some time, there were established regulations, which were faithfully observed. *Alcaldes*, magistrates, were elected, who decided on all disputes of right, or complaints of trespass, and who had power to summon juries for criminal trials. When a new placer or gulch was discovered, the first thing done was to elect officers and extend the area of order. The result was that in a district 500 miles long, and inhabited by 100,000 people who had neither government, regular laws, rules, military or civil protection, nor even locks or bolts, and a great part of whom possessed wealth enough to tempt the vicious and depraved, there was as much security to life and property as in any part of the Union, and as small a proportion of crime. The capacity of a people for self-government was never so triumphantly illustrated."*

On their way to California, whether they came overland or by sea, the adventurers learned many lessons of mutual tolerance and of self-government; while acquiring an indifference to the machinery of government, they became disposed to prefer a direct appeal to the community as the simplest, and therefore best, form of popular administration. The long voyage as members of an unruly company under an incompetent captain, and a similar experience with the immigrant

* Bayard Taylor, 'Eldorado', Vol. I, p. 67; 1850.

trains that threaded their way across the prairies, caused the young men to learn how to settle disputes, to appreciate the need for discipline of some sort, and to co-operate in maintaining order. If the wearisome journey did more to discipline than to educate, it served, on the other hand, to develop some measure of skill in self-government, and to induce a tendency toward short cuts as much for the preservation of order as for the summary punishment of those who infringed the frontier code. When they arrived at the diggings, the adventurers continued the associations, sometimes the partnerships, formed on board ship or in the covered wagons that became known as 'prairie schooners'. The stories of the golden days leave contradictory impressions; on the one hand we read of order, generosity, honor, and high aim; on the other we see pictures of riot, bloodshed, fraud, and frenzy. Neither extreme is altogether true, but the facts are given more reliably in the chronicles of the time than in the later reminiscences of garrulous pioneers. The life of the mining-camp, as Royce says,* was "the struggle of society to impress the true dignity and majesty of its claims on wayward and blind individuals, and the struggle of the individual man, meanwhile, to escape, like a fool, from his moral obligation to society". In such a frontier community, made up of men that had left their homes, their families, and their old vexations in an attempt to find a golden paradise, the social struggle came to the surface and was to be seen in its true light; for social duties of any sort are a nuisance amid the excited digging for gold, and to be a member of a vigilance committee in a roistering camp is better sport than to serve on a legal jury in a quiet town.

For nearly two years, however, from 1848 to 1850, the life of the diggings had many ideal aspects, as regards democratic government, orderly work, and cheery comradeship. During those two years only the most vigorous and resolute came to the gulches, no women disturbed the virile camps in the

* Josiah Royce, 'California, from the Conquest', p. 240; 1886.

hills, and the easy winning of gold made the miners generous to each other. They had no time to quarrel, the world was young, and life an epic. The population of the diggings by this time had grown to 100,000.

The social organization of these mining-camps in the foothills of the Sierra Nevada during the first two years of the golden era represents the nearest approach to genuine democracy that history records. Like shipwrecked mariners cast upon a lonely island they found themselves temporarily associated, as it happened, in this case, for the purpose of winning gold where apparently there was plenty of it. They had brought with them the spirit of the American frontier, a frontier that had slowly advanced across the continent, from sea to sea, during two hundred years.* That frontier spirit found expression in jurisdiction by popular tribunals and in the insistent establishment of self-government, even at the expense of efficiency. If a dispute arose, the diggers near-by dropped their picks, and, in prompt assembly, listened to the explanation of the quarrel. The verdict of the majority was accepted, and duly enforced. For more important matters, the call went forth, across the ridges and up the gulches, summoning all the men in the district to meeting. There the *vox populi* pronounced its ultimatum. These methods met temporary emergencies, and dealt with them in a manner so fair and yet so flexible that the camp laws survived after the rush. If the punishments, on occasion, seem to us today to have been brutally severe, we must remember that the association of men was essentially temporary; it was fortuitous, and it might come to an end any day; hence nobody was inclined to stop the digging for gold and join with the others in building a jail in which offenders could be incarcerated. Therefore, to suppress crime and protect property, it was found necessary to put a criminal either out of the world or out of the camp. The actions of the diggers were impelled not by cruelty, but by social exigencies.

* Mary Floyd Williams, 'History of the San Francisco Committee of Vigilance of 1851', pp. 66–87; 1921.

In the third year after the discovery there came many undesirable elements: the loose women, the gamblers, and the saloon-keepers. Another factor in promoting violence and disorder was a local exaggeration of the American dislike of foreigners, including the native Indians and Mexicans from whom the land had been but lately wrested. An amusing, but instructive, story is told of General Persifor F. Smith; he, while at Panama in February, 1848, had come to the decision, as we have seen, that the diggers were trespassers on the Federal domain, and that it was his solemn duty to expel them; but being sagacious, as well as solemn, he appreciated the fact that the force at his disposal was inadequate to keep all of them off the Government's property, and that their production of gold was stimulating national commerce. On the other hand, he decided that, while he might not be able, and perhaps ought not, to exclude all of them, he might exclude some for the benefit of those that were American. Therefore, when the ship 'California' arrived at Panama with 75 Peruvians on board, and a big throng of Americans was waiting to proceed to California on the overcrowded ship, they having come overland across the isthmus, he decided that trespassing, after all, was a thing of degrees, and was tolerable, when the trespasser was the right kind of fellow. Thereupon he issued an order to exclude foreigners from California. But the Peruvians refused to budge, and continued their voyage to San Francisco. The diggers themselves meanwhile had adopted regulations forbidding slave-owners, from the Southern States, to stake claims for their 'black bondsmen', that is, using the names of negroes to acquire extra claims for themselves. Likewise they would not allow the Chilenos, including Peruvians, to locate claims for their peons. The community of mines was to be for free men only. Later a tax of $16 per month was levied on all 'foreigners' working in the mines, but this local impost was not uniformly exacted. The Mexicans from Mexico itself, or Sonorians, as they were called, came in large bands, and took possession of some choice

ground on the Tuolumne, Stanislaus, and Mokelumne rivers; the feeling against them was so strong that they were ordered to leave; and they went, without resisting, but not without committing several outrages on the immigrant parties that they met on the way home. The treatment of the early French miners was outrageous; such acts may have "served to weld the Americans in a closer union", as Shinn says,* but it also bred a spirit of vicious intolerance that is strangely at variance with the miner's proverbial generosity. The Chinese were rigidly excluded; and had to wait their chance until much later, when they were permitted to pick up the crumbs that had fallen from the white man's table; in other words, they re-treated the refuse of the old diggings. In the decade 1848–1858 California yielded $555,000,000 in gold.

Among those who joined the rush to California was Edward H. Hargraves, an Australian squatter, of English birth. He sailed from Sydney in July, 1849, and arrived at San Francisco in October. Upon his arrival, Hargraves, who was then thirty-nine years of age, went to the diggings at Jamestown, on Wood's creek. The Australian noticed the similarity between the geologic conditions amid which gold was being found in California and those he knew to exist in New South Wales. He became eager to return to Australia, and discover gold there. Later he went to the diggings on the Yuba, where he did pretty well, but, he says: "The greater our success was, the more anxious did I become to put my own persuasion to the test, the existence of gold in New South Wales".† He sailed from San Francisco in November, 1850, and arrived at Sydney in January, 1851. On February 12, 1851, he discovered gold on Lewis Ponds creek, which flows into the Macquarie river. He found gold in many places and started the great rush to Australia. Thus the Californian discoveries stimulated the very beginning of the mining industry in Australia.

* Charles H. Shinn, 'Mining Camps', p. 7; 1885.

† Edward Hammond Hargraves, 'Australia and its Gold Fields'; 1855.

Another consequence of the discovery of gold in California and of its subsequent lavish production must be noted, for this played an important part in the history of the United States by giving invaluable assistance to the cause of the North during the Civil War. If the gold and silver produced in the States of the Pacific coast region during the years 1861–1865 had been turned into the coffers of the Confederacy, the result of the war might have been different. The loyalty of California to the Union ensured the use of this precious metal in preserving the life of the nation. The value of the gold and silver shipped from the western States during the years 1861–1864, inclusive, was $186,012,460. This enormous sum of money, or of metal equivalent to money, was placed at the service of the Union during the period of the conflict, and enabled it to meet its obligations confidently. One can only guess what might have happened if the gold had gone to the South instead of the North. As the silver of Laurium paid for building the ships that won the battle of Salamis for the Greeks against the Persians, so the gold of California paid for the military supplies that enabled the United States to remain a single nation.

CHAPTER III

MINING IN THE FAR NORTH

The early history of a country is linked with its topographic features. Mountains are barriers, rivers are avenues, the sea is a highway. The first Europeans to reach the northwestern corner of the American continent, now known as Alaska, came from Asia, for the Pacific Ocean provided an approach by means of the islands that like stepping-stones stretch far westward from the inhospitable shore of the mainland.

The Russians crossed Siberia and explored the Arctic coast of Asia. In 1728 a band of Cossacks was driven by a storm eastward from Kamchatka, and landed in Norton Sound.* Others followed them, and settled on the islands and peninsulas of southeastern Alaska. The mountains guarding the coast discouraged any advance into the interior. Another range, the northern extension of the Rocky Mountains, barred the westward progress of the French *voyageurs* and the English fur-traders of the Hudson's Bay Company. After the Russians had obtained a foothold among the Indians, the viceroys of Mexico sent successive expeditions up the coast, such as that of Pérez in 1774 and of Heceta in 1775. If the English fur-traders had not interfered, the Spanish and Russian spheres of influence would have conflicted, and the contest for control might have ended in establishing a line of demarkation somewhere near the mouth of the Columbia river. The British navigator Captain James Cook landed near Sitka in 1778 while seeking a way by water to Hudson Bay. Fifteen years later his midshipman, George Vancouver, in command of another British expedition, surveyed the coast

* T. A. Rickard, 'Through the Yukon and Alaska', p. 10; 1909.

carefully from 35 to 60 degrees north latitude. Meanwhile the English also were beginning to find a way overland from Canada. Alexander Mackenzie, in behalf of the Northwestern Fur Company, started from an outpost on Lake Athabasca, ascended the Peace river, crossed the mountain barrier, and reached the Pacific tidewater in Queen Charlotte Sound in 1793—and just missed meeting Vancouver! Thenceforth the northwestern corner of North America, from Unalaska along the fringe of islands to Sitka and thence to British Columbia, was the battle-ground between the agents of the two fur companies, namely, the Russian American Company and the Hudson's Bay Company. Not until 1826 did the Russians extend their exploration along the coast of Bering Sea to the mouth of the Yukon. The establishment of a post at St. Michael prepared the way for trade up the Yukon, the great river of Alaska. In 1843 Zagoskin reached the Tanana and built Nulato.

While the Russians were exploring the western coast of Alaska, the English were finding their way east of them to the Arctic. In 1789 Mackenzie descended the river that now bears his name and reached the frozen sea. In 1826 Sir John Franklin went westward from the mouth of the Mackenzie. When he was lost, the successive relief expeditions sent from England between 1845 and 1853 explored and charted portions of the Seward peninsula. The great interior region was still unknown, although the Hudson's Bay agents were persistently advancing their outposts westward. In 1840 a factor, or agent, of that company established a trading-post at the head of the Pelly, a tributary of the Yukon. In 1847 Fort Yukon was built by McMurray. The English traders heard that the Russians were in the lower Yukon, and in 1850 they descended the river to Nulato. Thus here and there at enormous distances apart the lonely outposts of the European peoples were gaining a foothold. The only purpose of their intrusion into the inhospitable wilderness was the trade in furs. No whisper of gold was yet heard.

In 1863 the Western Union Telegraph Company sent an expedition to survey a telegraph line that was to connect America and Europe by way of Asia. At that time submarine transmission by cable under the Atlantic was believed to be impracticable. The survey of the proposed route through British Columbia, Alaska, and northeastern Siberia involved the exploration of regions but little known. In Siberia, George Kennan did good work;* in Alaska, Robert Kennicott was the leading spirit.† Although the project of an overland telegraphic system was nipped in 1867 by the announcement that the Atlantic cable was a success, the explorations made then and thereafter by the men in charge of the Western Union expeditions proved most useful. They ascended the Yukon, and they crossed the Seward peninsula. The information they procured proved of great value in the negotiations between the American and Russian governments for the transfer of Alaska to the United States, and the routes they mapped were followed by the telegraph lines that were established as soon as the country came into prominence in consequence of the gold rushes.

In 1867 Russian America was purchased by the United States for the sum of $7,200,000, and the 'district', at the suggestion of William H. Seward, the Secretary of State, was named Alaska. At that time the finding of gold had been reported in a vague way, but no profitable mining had been done. The fur-traders, having no experience in mining, looked for gold in the bars of the big rivers and not in the side canyons of the smaller streams in which gold was found later in abundance. The Indians, it is true, like primitive man elsewhere, had picked up bits of gold and lumps of native copper on the edges of the streams that were their natural highways, but these pieces of metal were used only for ornament and had relatively little value. In

* George Kennan, 'Tent Life in Siberia'; 1870.

† Frederick Whymper, 'Travel and Adventure in the Territory of Alaska', p. 89; 1869.

1880 two nuggets were obtained by barter from an Indian at Nulato. But such pretty specimens awakened only a languid interest on the part of the trappers until they were joined by prospectors that had wandered northward from British Columbia.

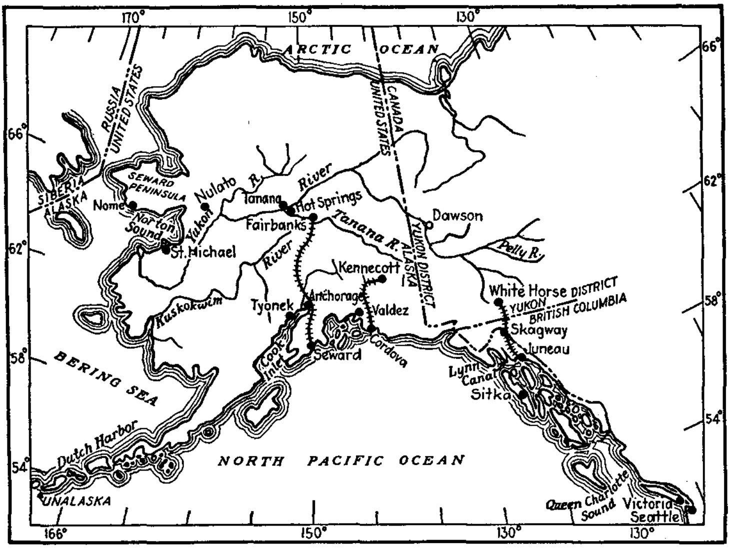


FIG. 2.—Alaska.

Up to the date of the transfer of Alaska from Russia to the United States, there had been no gold-mining in the territory. The Russian governors discouraged the search for gold because it might interfere with the fur-trade, which was their source of profit. Some old records prove that the Russians had indeed noted the occurrence of gold in several localities, but they had made no systematic effort to exploit the deposits. P. P. Doroshin, a Russian mining engineer, was sent by the Russian Government in 1848 to explore the mineral resources of the territory; he found gold on the Kaknu [Kenai] river, which empties into Cook inlet, and he brought back 40 ounces, which, however represented the

labors of as many men for several months, and therefore was deemed an unpromising effort.* Afterward he was bitterly reproached for his failure to discover any workable gold deposit, but he was handicapped by the lack of aid from the natives, who, he said, had no word for gold.† The Stikine river was invaded by prospectors in 1865, and in 1874 the Cassiar diggings were started on the Canadian side, but these events created no stir. In 1869 a party of disappointed prospectors, headed by Mix Sylva, traveled northward from Fort Wrangell and discovered placers on Windham and Sumdum bays.‡ It is reported that $40,000 was taken from these diggings in the two following years. This was the first gold-mining in southeastern Alaska.

The old Russian capital was Sitka, on Baranof island, where mining began in 1877 with the location of the Lucky Chance and Stewart claims on Silver bay. One of the locators of the Stewart was George Pilz, who erected the first ten-stamp mill in Alaska at that mine in 1879. At this time John Muir was deputed by the United States government to explore southeastern Alaska, and in his report he stated that the region between Windham bay and Sullivan island was destined to be a second California. The report, in pamphlet form, came to Sitka in the spring of 1880, and was read by Pilz, who had just completed his little stamp-mill. He and N. A. Fuller, a local merchant, after reading Muir's report, decided to send prospectors into the district recommended by the distinguished naturalist. They chose Joseph Juneau, a French Canadian, and Richard Harris, an American. Accompanied by three Indians and well equipped, these two started on July 19, 1880.

* Ivan Petroff, 'Report on the Population, Industries, and Resources of Alaska', p. 115; 1884.

† P. P. Doroshin, *Archiv für wissenchaftliche Kunde in Russland,* Vol. XXV, p. 225; 1866.

‡ Charles Will Wright, 'The Juneau Gold Belt, Alaska', U. S. Geol. Survey, *Bull.* No. 287, p. 2; 1906.

From Sitka they went in a small boat to Windham bay, to the Taku inlet, and to the Lynn Canal, and when they came south again their boat ran aground on a bar in Gastineau Channel at the north end of Douglas island, nearly opposite the present site of Juneau. Then they crossed to the mainland, where they found gold at the mouth of a small stream, which they named Gold creek. The date was August 17, 1880. They went up this stream to Silver Bow basin and discovered several rich quartz veins, which they covered with their locations. Being now short of provisions, they returned to Sitka, but shortly afterward they went back to Gold creek, where, with the aid of the Indians, they cut a trail and packed 800 pounds of ore, with which they returned to Sitka in November.

Juneau and Harris were intelligent fellows; they gave a frank account of their discoveries,* the news of which promptly caused a rush to Gold creek, where a town-site, now the city of Juneau, was located. In the spring of 1881 the Northwest Trading Company sent Edward de Groff to open a store, which served also as the post-office. A mining district was duly organized in February, 1881. In April, John Olds went up Gold creek and above its source in Silver Bow basin to the ridge that rises on the eastern side. On the mountain slope he found the outcrops of the Perseverance and Groundhog lodes. He told the present writer that wherever the snow was gone he saw lots of loose 'float' in which gold could be seen. The veteran acknowledged that he became excited, and thought he had found "the richest country on earth". How many times have our other prospector friends thought likewise! He located several claims, but when the experts arrived and condemned the discovery, he neglected his locations, which in later days marked the scene of mining operations on a tremendous scale, as we shall see in due course.

The Chilkat Indians opposed the incoming prospectors until 1880, when 16 men, led by Edmund Bean, crossed the

* H. H. Bancroft, 'History of Alaska', p. 739; 1886.

Chilkat pass and descended the upper waters of the Yukon. In 1883 Frederick Schwatka crossed the same pass and followed the Yukon all the way to the sea. His graphic account* of the expedition appeared in the 'Century' magazine, and did much to excite interest in Alaska. He mentioned the occurrence of gold in several localities, notably at the mouth of the Pelly river,† but he deemed such discoveries as of no consequence in comparison with the fur-trade, which was still highly profitable. The sables of the Yukon were of the best quality, and the traders of the Hudson's Bay Company had established posts at several places along the great river as early as 1873, one of these being Fort Reliance, six miles below the junction of the Klondike with the Yukon. Many of the early prospectors that explored the region used to spend the winter at this post.‡

Edward Schieffelin, who discovered the silver deposits of Tombstone, Arizona, went, in 1882, with his brother to Juneau, and, later, in a small boat he voyaged first to St. Michael and then a thousand miles up the Yukon, where he spent a year in prospecting. He found some shot gold on the Melozecargut, or Monday river, near Rampart, where he and his party remained until August, 1883, by which time he had come to the conclusion that the shortness of the season and the difficulty of obtaining supplies were disadvantages that would have to be compensated by a prospect of unusual richness.

The first profitable diggings in the valley of the Yukon were on the Stewart river, where some rich bars were discovered in 1885, but soon the report of coarse gold having been obtained lower down the valley caused the men on the Stewart to decamp with characteristic haste for the new Eldorado. This was at Forty Mile—that is, 40 miles from Fort Reliance—where a prospector named Franklin made

* Frederick Schwatka, 'Along Alaska's Great River', 1885.

† Frederick Schwatka, 'A Summer in Alaska', p. 317; 1893.

‡ Tappan Adney, 'The Klondike Stampede', p. 237; 1900.

his discovery in 1886. Until 1893 the gulches in this district yielded most of the gold that came from these parts.* In 1892 a Russian half-breed discovered gold on Birch creek, farther down the Yukon, and many of the men at Forty Mile went thither, their new camp becoming known as Circle, because it was close to the line of the Arctic Circle. The Forty Mile district was partly within Canadian territory, but Birch creek was wholly American.

The gold was found on bedrock, underneath a few feet of gravel, which was removed by shoveling. Where the overburden of barren gravel was too thick for shoveling it became the practice to sink shafts by aid of wood fires, for the ground in the Alaskan interior is frozen perennially. The fire thawed the gravel, so that it could be shoveled, and then hoisted to the surface, where it was washed in sluice-boxes during the summer season. These early diggings were not rich, and the shortness of the season was a handicap to systematic operations; moreover, the remoteness of the mines and the precarious character of the food-supply checked enthusiasm. In 1896 the annual output of gold from the Yukon region was about a million dollars, of which nearly a third came from Canadian territory. The international boundary is 50 miles below Dawson, where the waters of the Klondike mingle with those of the Yukon. Up to that time therefore this vast watershed was of no consequence as a mining country; its products were fish and furs; then, suddenly, as out of a clear sky, came the tremendous shout of a great gold discovery.

On July 14, 1897, the steamship 'Excelsior' arrived at San Francisco with a number of miners carrying sacks of gold 'dust' valued at $500,000. Three days later the 'Portland' unloaded $1,000,000 in gold on the wharf at Seattle. The happy diggers told stories of a new Eldorado in the North, in the valley of the Klondike, on the edge of the Arctic. The news was flashed round the earth, and the response was prompt. Within a few months 33,000 gold-

* J. E. Spurr, 'Through the Yukon Gold Diggings', p. 110; 1900.

seekers landed at Skagway on their way to the diggings. In eager procession they climbed the passes that led over the coast range to the headwaters of the Yukon, down which they voyaged in boats and rafts to Dawson. In 1898 the Klondike district yielded $10,000,000, and in 1901, $22,000,000. The total output has been about $200,000,000.

Many Americans participated in this stampede, and in the more systematic development of a later day, but the Klondike is not within American territory, and therefore does not come within our purview at this time. In the wake of the Klondike rush, however, there came other finds of gold in the North, chiefly in Alaska itself, in American territory.

The most remarkable of the Arctic diggings were those at Nome, which became the scene of operations unlike any other in the history of mining. The story centres round the three lucky Swedes, as they were called, although one of them, Jafet Lindeberg, was a Norwegian, who came to Alaska in charge of the herd of reindeer that the American government caused to be brought thither from Lapland in 1898. Of his two comrades, John Brynteson had worked in the iron mines of Michigan, while Erik Lindblom had been a tailor in San Francisco. They chanced to meet, in September, 1898, at Council, on the Seward peninsula, which projects into Bering Strait toward the northeastern extremity of Siberia. All the available alluvial ground in the Council district had been staked by the 'stampeders' on the way to or from the Klondike, so they decided to go elsewhere. Lindblom reported that he had found gold in the coastal plain not far to the north, so the three adventurers procured a boat and the necessary provisions, with which they sailed for a hundred miles along the coast until they came to the mouth of the Snake river, near Cape Nome. The chill gray waters, under a cloudy sky, lapped a long beach fringed by the moss-covered plain, the Arctic tundra, which stretched drearily inland to a low line of forbidding hills. The gravel on the edge of the river, and even the beach sand, showed some gold, but

the prospectors inferred correctly that it came from richer deposits up-stream. So, in their boat they ascended the meandering waterway as far as was practicable, and then on foot they explored the valley and began to test the tributary creeks systematically. The names of those creeks to an Alaskan are now as eloquent as Colchis and Pactolus to Macaulay's schoolboy.

Although novices in mining, these three Scandinavians selected what proved to be the richest portions of the creek-beds; they located a joint discovery claim and then three other claims in their separate names, first on Anvil creek, and then on Snow, Glacier, and Rock creeks. They knew what they were about; they showed good judgment in their locating, and they took pains to comply with the law. When they returned to Council, in October, the news of their discoveries soon spread, causing a rush. The Nome mining district was organized forthwith, and the whole country was soon plastered with locations, most of which were illegal. The prospectors that had done the first mining on the Seward peninsula were chagrined to find that the three Swedes, comparatively inexperienced as they were, had pegged the best claims; whereupon they 'jumped' the claims of Lindeberg and his partners on Anvil creek, and set an example that was followed at once by the crowd of newcomers. Every claim was covered, two or three deep, with locations. Anarchy ensued, culminating in a disgraceful litigation, rendered long and costly by a conspiracy among the local authorities at Nome. Never was the law worse prostituted by scoundrels, and never did a man fight more courageously against big odds than Lindeberg in behalf of his 'prospecting comradeship'. To the honor of American journalism be it said that the 'Washington Post' was instrumental in exposing the shameful story, and causing the Senate to demand an investigation. The Federal Court at San Francisco checked the outrage and prevented the robbery from being consummated. Lindeberg and his associates came into their own, after a

fight that had lasted three years. The Pioneer Mining Company, which became the owner of their consolidated holdings, produced $17,000,000 in gold, from which $6,000,000 was paid in dividends. Lindeberg did not forget his native place, Tromsö, in Norway, but gave money for building schools there, so that his younger countrymen might obtain the educational training that he had been compelled to acquire as best he could during the rough and tumble of his mining life.

In 1899 some of the gold-seekers that congregated on the seashore at Nome were disgusted to find that all the creeks were plastered with location notices; fortunately for them, the gold was not only in the creek-beds, but also in the detritus under the moss at the edge of the plain where it was broken by the wash of the waves; no exceptional intelligence was needed to impel an idle digger to test the beach sand, which was, it seemed, open to anybody. Early in June a soldier found that the beach contained gold in paying quantity; it was a mine! Soon scores of men went to work feverishly with pan, shovel, and rocker; as much as $200 in a day was gathered by individuals; two men won $1100 in two months; during that summer $1,200,000 was recovered from the beach. The next year, of course, there was a rush thither, and a white-tented city, like a snow-drift five miles long, fringed the shore of Bering Sea. In the summer of 1900 there were 30,000 people at Nome; the output of the district, including the creeks, during that season was $4,750,000. The beach itself has yielded altogether about $5,000,000.

As might be expected "the golden sands of Nome" were admirably adapted to reckless promotion and flamboyant finance. Companies were formed without limit and shares were sold without stint; if individuals without machinery could earn $10 to $20 per day by mere digging on the sea-beach, it was obvious, so purred the promoters, that with machinery and expert knowledge the winnings would inevitably be tremendous. Every kind of gold-saving device was

brought to Nome, from patent cradles to cumbrous dredges; the shore became littered with fearsome machines, which might still survive as monumental follies if a big storm had not smashed them and swept them over the tundra. A few linger in sheltered spots, a warning to the unwary.

Soon after the digging on the beach had been started, the owners of claims on the adjacent tundra asserted that they were the legitimate proprietors of the marine alluvium; in compliance with the demand of sundry rich companies, three hundred miners were arrested by the military force posted at Nome, but they were soon released because there was nowhere to lodge them and nobody to feed them. Later the Government asserted its right of possession, the shore being a Federal reservation; no claims therefore might be located, but a man could hold a patch of ground so long as he was at work, on the tacit agreement of his fellow-workers. So the digging continued during summer for many years thereafter, and even as late as 1907 a hundred men were earning $3 per day on the beach. The gold obviously has been derived from the seaward edge of the coastal plain, itself an alluvial fan created by deposition of the detritus brought down from the gold-bearing hills eastward. The tide concentrates the gold upon a layer of clay that underlies the sand; a storm scatters the gold and throws it on the surface of the beach, to gladden the heart of man. At one time it was imagined that this deposit of golden sand extended under Bering Sea and across to Siberia, 175 miles distant; indeed, in 1900 an expedition under Russian guidance, but financed by an Anglo-American syndicate, was sent to find the other end of the marine placer. The enterprise served, as Huxley said, apropos of Spencer's idea of a tragedy, to illustrate how a pretty theory may be killed by an ugly fact.

The rush to Dawson and to Nome brought many enterprising men to the Yukon watershed and led eventually to the discovery of gold in places scattered far apart in this northern wilderness. One of the richest diggings was on the

Tanana, which enters the Yukon at Fort Gibbon. The story of discovery has two threads, drawn by Barnette and Pedro respectively. In the spring of 1901, E. T. Barnette, who was called Captain because he commanded a boat in which he brought a stock of goods for sale, came up the Yukon from St. Michael and ascended its tributary stream, the Tanana, with the intention of establishing a trading-post. He found a suitable site and unloaded his goods on August 24, 1901. Meanwhile a party of five men, led by Felix Pedro, had started across country from Circle, which was 175 miles northeast of Barnette's camp. Before they arrived they had exhausted their food supplies and were living on berries and game. On July 27, 1902, Pedro made the first discovery at the head of Gold Stream; he picked up some bits of gold in the bed of the living stream and then sank a hole into the frozen ground to one side, where he found more gold in the gravel. The camp was named Fairbanks in honor of a Senator that subsequently became Vice-President of the United States. In September, 1902, there arrived Wadda, a Japanese, a redoubtable character, who, in January, 1903, carried the news of the discovery on Gold Stream to Dawson; whereupon a stampede ensued. Eight hundred men left Dawson during the next three months. They were a disorderly lot, not genuine miners; when they reached Fairbanks they were disappointed to see so little gold, and wanted to lynch Wadda. They also threatened an attack on Barnette's store, but a few well-armed men thwarted this purpose. Frustrated, most of them departed down the Yukon in small boats and rafts, bearing with them bad reports concerning the diggings, so that supplies intended for the traders at Fairbanks were either diverted to other points or countermanded altogether. In consequence, a severe shortage of food was experienced by the people at Fairbanks during the ensuing winter, and many would have died of starvation if fortunately great herds of caribou had not crossed the district in their annual migration southward.

Shortly afterward the rich alluvium of Cleary creek was discovered, and everybody had a chance to become rich. With the first snow that fell in the autumn of 1904—in October—a boiler of 40 horsepower was hauled to the creek and set up on No. 1 Below, which means the first claim below the one located by the discoverer. A boiler was a prime requisite to the miner in Alaska because he needed steam to thaw the frozen ground. The Alaskan interior is still in the grip of a Glacial period; the surface is covered with moss, named 'tundra' by the Russians; under this comes a blanket of frozen mold, called 'muck' by the Americans, because when thawed it is converted into liquid mud. Under this is the gravel, also frozen solid, which extends to bedrock, where lies the gold in concentrated form. It is impossible to reach the gold-bearing sediment on bedrock by means of pick and shovel, nor will ordinary explosives serve to aid the miner in sinking the necessary shaft. What could the miner do? He could overcome cold with heat. He laid bundles of sticks on the ground and made a fire that melted the frozen ground, so that it could be broken and shoveled. By repetition of this procedure the hole became a shaft. But such work was tedious and expensive. An alternative method was discovered by accident; in 1898 C. J. Berry noticed that the steam escaping from the exhaust of his engine had bored a hole in the ground; he picked up the exhaust-pipe, which was a rubber hose, and ascertained that the steam would thaw the ground to full length of the hose within a few minutes. Eureka! At once a suitable device was constructed; a rifle barrel was chosen and a small hole was bored in one side to admit

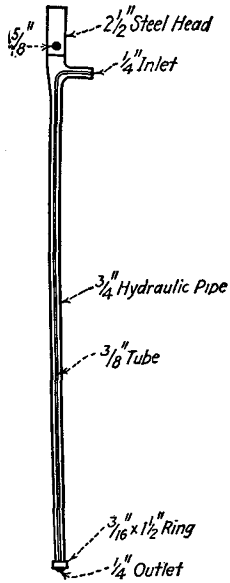


Fig. 3.—A steam-point.

the steam. Thus was the 'steam-point' invented. In its rudimentary form it consisted of a short length of iron pipe, pointed at one end, and at the other attached to a rubber hose leading to a boiler. The pointed end of the five or six feet of pipe was driven forward by taps from a hammer as the ground was softened by the jet of steam. In later years it was discovered by John H. Miles that cold water was better than steam, because it was cheaper and because it was effective over a wider range.* A solid head was added to the butt end and a protecting ring was welded to the forward end; the shank was made of special pipe and armored tubing replaced the ordinary hose. The cost of thawing by means of this device was from 30 to 50 cents at first; subsequently it was reduced to 10 or 15 cents, per cubic yard.

The frozen condition of the placers in Alaska proved in the end to be useful in many ways. The miner could sink his shaft even in the bed of the creek, without having any water to pump; he was excused from using timbering; he could burrow with safety and follow the layer of gold-bearing gravel with impunity under the ice-bound surface.

The methods employed in mining the frozen ground are illustrated by the operations at No. 11 Below on Cleary creek, as I saw them in 1908. The shaft is 7 feet square and 70 feet deep; in order to make a sump for collecting the seepage from thawing, the shaft has been sunk 10 feet below the surface of bedrock. Then a drift, 6 feet wide and 6½ feet high, has been excavated up-stream along the top of bedrock for a distance of 200 feet, to the boundary of the claim. This drift or gangway is timbered. From the main passage a number of cross-drifts extend at right angles on both sides to the limits of the gold-bearing sediment of the alluvial channel, which here is from 240 to 300 feet wide. This development work being completed, the miners begin to remove the frozen gravel lying on bedrock, using the

* Walter S. Weeks, 'Thawing Frozen Gravel with Cold Water', *Mining and Scientific Press,* Vol. CXX, p. 367; 1920.

'steam-points' already described. The 'points' are first fed with hot water while they are being driven into the ground, and when they have been forced to their full length, the water is replaced by steam for 24 to 30 hours. This is the 'sweating' period, during which the frozen sediment is thawed around each point for a space 2 to 2½ feet wide. When the ground has been softened, the 'points' are withdrawn, and the miners use their picks to break the gold-bearing material so that it can be shoveled into wheelbarrows, which are then trundled to the shaft. There the 'dirt' is discharged into a bucket and hoisted to the surface, to be washed in sluice-boxes during the genial days of summer. Even in this sub-Arctic region the temperature rises above 90°F. in July; the air is pleasantly warm when the ground underfoot is still held in the grip of a Glacial cold. In the course of these operations the miners remove about one foot deep of the bedrock and from five to six feet of the overlying gravel. The gold-bearing sediment is from a few inches to three or four feet thick. The excavation of the top of the bedrock is made necessary by the fact that the gold has found its way into the cracks and crevices of the rock, which, fortunately, is so decomposed as to be soft and therefore easy to dig.

To go underground we* stood erect on the edge of the bucket and grasped the steel rope, while being dropped quickly to the bottom of the shaft. Lighting our candles, we walked along the boarded way over which the wheelbarrows pass. Having been warned of their approach, we stepped aside with our backs to the side of the level while the procession of six men trundling their barrows proceeded to the shaft. Each barrow holds 15 cubic feet, or 375 pounds of gravel, six of them being required to fill the bucket of the hoist. The men are paid $5 and their board, which is worth $3 per day, so that each worker costs the mine-owner $8 per day. Each man excavates, shovels, and wheels his own share of the output of the mine at a pace regulated by the

* Not the editorial 'we'; Scott Turner was my companion.

leader, who is chosen by the manager for that purpose. Turning into a cross-drift, we entered a low cavernous chamber made in the course of mining. There we saw 38 'points' silently at work, with nothing to indicate the process, for any leakage of steam is carefully prevented. Such leakage not only entails waste of energy, but it causes the air of the mine to become heated so as to thaw the roof, with consequent falls of the overburden. Everything is frozen hard. The air has the feel of a cold-storage chamber. In walking through the workings one hears the occasional dropping of the gravel that has been loosened by such warming of the air as is due to the bodies of the miners and to the steam-pipes.

The mines were worked mainly by lessees; fully three-quarters of the gold won in the Fairbanks district in 1908 was being taken out of the ground by 'lay-men', who paid the owners of the claims a tribute of 25 to 50 per cent on the gross output. For this large proportion of the yield the claim-holder had usually done nothing except to locate the ground or have it located for him. Of the hundreds of lucky mine-owners in the district, only a few made a discovery of gold themselves and only a few ever did any real work themselves. Many of the claims were located under power of attorney, and in some instances, by the abuse of this privilege, a few men had been enabled to acquire large areas of profitable ground. A miner could go up a creek and stake for himself and his friends as many claims as he liked, provided he made a discovery on each claim of 20 acres; although, as a matter of fact, a true discovery was rarely made, for the simple reason that the gold was thirty or forty feet underground, and a shaft was not sunk to bedrock until many days after the legal formalities of 'location' had been completed. Moreover, a man could stake an 'association' claim of 160 acres, using the names of eight men and making only one suppositious discovery. This is a striking example of the unearned increment and of special privilege under a republican government, not infrequently named a democracy. By virtue of

power of attorney a locator used any names he pleased, the fiction involving no permission or legal authorization from the owner of the name. In this manner Alaska was plastered with claims belonging to men that did nothing while others did the work from which the idle owners gathered a rich tribute of gold.

While the alluvial diggings were attracting crowds of adventurers, the less spectacular winning of gold from lodes that reached into the crust of the earth had been started successfully in southeastern Alaska. Incidentally, it may be noted that none of the rich placers were linked with gold veins of comparable productiveness, although, in accord with experience elsewhere, the miner expected to find the stumps of the veins or lodes that by becoming weathered and eroded by geologic agencies had contributed the gold occurring in the alluvial deposits. Such veins were found in Silver Bow basin, which was first prospected, as we have seen, by Juneau and Harris, in 1880. The placers in this locality proved the more productive in the early days, so that the mining of the ore in the hillside was postponed to a later day. However, when Juneau and Harris came to Sitka with their news concerning Gold creek, a French Canadian, named Pierre Erussard, decided to go forth on a similar quest. He had been living with the Indians while engaged in prospecting, and when he left Sitka he was accompanied by several of them, among whom was his squaw's brother. In November, 1880, they landed on Douglas island, which is separated from the mainland by Gastineau Channel, and is opposite the town of Juneau. Pierre and his Indian comrades found gold in the beach sand; they also discovered an outcrop of gold-bearing quartz on the hillside, about a quarter of a mile from the shore. He located two claims, one named the Paris, after the capital of France, and the other the Bear's Nest, because he found the ground occupied by a bear and her two cubs. The loose quartz of the outcrop was shoveled by Pierre into his sluice-boxes, and a little later he drove a shallow adit, or

tunnel, to cut the lode a few feet below the moss-covered surface. This was the first mining on Douglas island. Pierre continued to wash gold out of the small placer formed by the concentration of the detritus eroded from the quartz outcrop, and he dug into the surficial part of the lode itself where it was soft, washing this product also in his rocker and sluice-boxes. He did fairly well, but it was no bonanza, compared with Gold creek; therefore he sold the better of his two claims, the Paris, to John Treadwell, in 1881.

John Treadwell was a carpenter and contractor with some experience in mining, for as early as 1869 he had worked in White Pine county, Nevada, and for 12 years before going to Alaska he had been engaged in both lode and alluvial mining in Nevada and California. In 1881 he was building a house in San Francisco for John D. Fry, a banker. To Colonel Fry and his friend James Freeborn there came a tale of a rich prospect in the hills behind Juneau. They decided to send Treadwell thither, promising him a third interest if the business was consummated. Treadwell went north, saw the prospect, and found that it was a stringer of quartz carrying free gold. This small vein was in the slate close to the present Ebner mine, in the Silver Bow basin, and eventually formed part of the great Alaska-Juneau property. Treadwell saw that most of the rich ore had been dug out and decided that the prospect was unattractive. Disappointed, he prepared to return to San Francisco, but while awaiting a steamer to take him back he met Pierre Erussard in the little store he had started at Juneau. Pierre happened to need some money to pay freight charges on supplies that had just arrived from the south, so he was willing to take $500 for an interest in his mine on Douglas island. Without going to see the claim, Treadwell 'took a flyer' and advanced $500 from the funds intended for the purchase of the other prospect. Then he went across the water to see Pierre's mine and was so favorably impressed that he took a bond on the Paris claim for $20,000. Having made this deal,

Treadwell went to San Francisco, whence he returned on May 17, 1882, with a five-stamp mill, which he set to work on the Paris claim. Fry and Freeborn completed the deal, and Treadwell got his third interest. A few years later Freeborn sold his share to D. O. Mills, a financier of high standing. The Alaska Mill & Mining Co. was formed, and operated the mine until June 1, 1890, when the Alaska Treadwell Gold Mining Co. was incorporated under the laws of Minnesota. In deference to his business ability, Mills

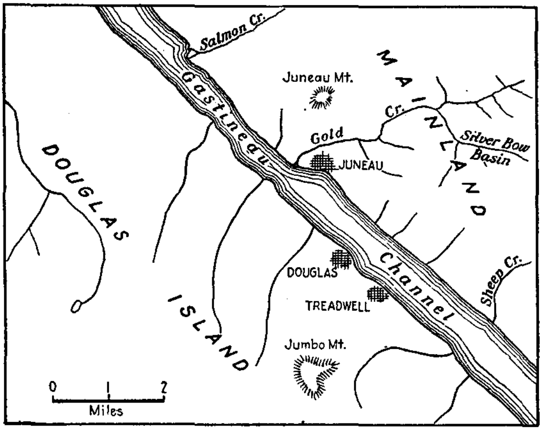


FIG. 4.—Douglas island and Gastineau Channel.

remained in control although in 1890 the Exploration Company, of London, on the advice of Hamilton Smith, acquired a major interest. The Exploration Company was the chief of the many English financial groups that bought and worked American mines on a large scale during the last decade of the nineteenth century. Hamilton Smith became consulting engineer to the Treadwell company; he was followed successively by H. C. Perkins, Thomas Mein, and F. W. Bradley, all of whom achieved notable distinction in their profession.

In 1883 work was begun on the first large mill, of 120 stamps, which was completed two years later. In 1887 the

number of stamps was doubled, all under one roof. In 1893 and 1899 the subsidiary companies, owning the adjacent ground, in the names of the Mexican and United corporations, erected their own mills, and a new 300-stamp mill was added by the parent company, the Alaska Treadwell Gold Mining Company. By that time 880 stamps, under the same management, were treating the ore of the lode. In 1908 they were crushing 1,360,000 tons of ore, yielding $3,250,000 per annum. At that time the ore reserves of the Alaska Treadwell were estimated to be 4,664,742 tons, of which 709,055 tons lay broken in the stopes. The 32 machine-drills in the mine were breaking 29·35 tons per drill per shift, the maximum duty being 54·68 feet drilled and 53·9 tons broken per shift.*

Until 1895 all the ore came from the big excavation known as the 'glory-hole', dug in the lode for a length of 1400 feet, a maximum width of 420 feet, and a maximum depth of 580 feet. This huge open-cut yielded 5,086,500 tons of ore, up to 1905. The 540 stamps of the Alaska Treadwell company crushed from 2750 to 3000 tons daily, or about 5½ tons per stamp. In 1908 the ore contained $2·35 in gold, of which $2·15 was recovered, leaving only 20 cents in the discard. The cost of milling ranged from 12 to 22 cents per ton, the lowest figure referring to the newest mill. The total cost of mining and milling, together with general expenses, was only $1·35, so that a profit of 43 per cent was made on the assay-value of the millstuff. During the year ending May 31, 1908, the Alaska Treadwell mine yielded 743,097 tons of ore, from which $887,509 as gold in amalgam and $736,636 in concentrate was obtained, making a total output of $1,624,145. Of this, $577,493 was profit. Up to that time the mine had yielded $22,359,934, of which $10,438,933 had been profit.

An economic tragedy was impending. The method of mining underground, as distinguished from the open-cut, was an application of the overhead system of stoping, in the course

* *Mining and Scientific Press*, Vol. XCVII, p. 750; 1908.

of which pillars of rock were left to support the excavations.* When a stope was being cut, the miners stood on broken ore, only enough being drawn on the level below to keep the men within reach of the 'backs', which were arched so as to diminish the tendency to cave. Ore was stoped to a maximum width of 250 feet; in places it was removed for a width of 160 feet along a distance of 300 feet, creating large voids. Unfortunately, when the ore was drawn the stopes were not filled with waste, in consequence of which an enormous pressure developed on the hanging wall, and this became concentrated on the pillars, some of which collapsed, and caused caving on a large scale. This was followed by falls of rock from the surficial openings and eventually by subsidence, which became manifest by cracks, through which the sea-water began to seep into the mine. Over 340,000,000 cubic feet of rock had been removed in the course of mining operations during 45 years. The water of the mine became increasingly salty—an ominous sign! In 1916 it was ascertained that the inflow of salt water was at the rate of 39 gallons per minute. An effort to check this inflow was made by dumping tailing from the mill, to fill any cracks in the sea-bottom. The drawing of ore from the upper workings was decreased.† To facilitate measures of safety the three companies were consolidated in 1916. These precautions were too late, and proved unavailing; on the night of April 21, 1917, the beach subsided and large cracks appeared on the shore. Water poured into the mine, and the workings were drowned completely. Fortunately the catastrophe had been foreseen, so care had been taken to save the men underground, not one of whom was lost. A number of horses and mules employed on the lower levels, however, were entombed. Two of the company's houses, a natatorium and a fire-station, were engulfed within the opening made by the caving of the surface.

* T. A. Rickard, 'Mining the Treadwell Lode', *Mining and Scientific Press*, Vol. XCVII, p. 85; 1908.

† *Mining and Scientific Press*, February 10, 1917.

Many other buildings cracked or collapsed, but, again, no lives were lost. The great enterprise was dead. Up to June 1, 1916, the Treadwell group of companies had treated 26,464,047 tons of ore for a yield of $62,797,460, the average yield being $2·37 per ton, the average operating cost $1·42 per ton, and the dividends 80·5 cents per ton, making a total profit of $21,303,557. But this does not measure the industrial benefit of the operations, because for the time of a generation this mine served as a point of departure for discovery and development in the surrounding country, out of which came other useful enterprises that contributed to the welfare of the people of southeastern Alaska.

CHAPTER IV

LOW-COST GOLD-MINING

Forty-three years ago a record for low cost was made at the Spanish mine, in Nevada county, California. In 22 days of September, 1887, there was mined 2796 tons of ore at a cost of 37·5 cents per ton, of which 32·4 cents was for labor and 5·1 cents for supplies. The mill treated this ore for 23 cents per ton, of which 12·3 cents was for labor and 10·7 cents for supplies. Thus the total operating cost was 60·5 cents per ton. The yield was $1·16 in gold per ton, leaving a profit of 56 cents per ton, or 48 per cent of the yield. The mine was an open-cut in a schist formation on a hillside and the work was done by Chinese laborers that were paid $1·40 per shift. The ore was soft, and could be ground effectively in four Huntington mills, supplemented by silvered amalgamating plates.* The engineer in charge was F. W. Bradley, a student from the University of California. As has been indicated, the conditions were unusually favorable in respect of softness of ore, accessibility to the mill, metallurgic simplicity, with cheap labor and power, but even at that the results were so remarkable as to attract general attention, which, as might be expected, was magnified, for advertising purposes, by the manufacturers of the Huntington mill, the firm of Parke & Lacy, at San Francisco. The record made at the Spanish mine therefore found its way into many textbooks on mining published at that time.

The editor of the 'Mining and Scientific Press'† (at that date, Charles G. Yale) evidently took a warm interest in the

* *Mining and Scientific Press*, October 22, 1887.

† This technical periodical, published at San Francisco, was started in 1860, and was consolidated with the 'Engineering and Mining Journal' of New York in 1922.

good work done at the Spanish mine, for, in the issues of November 26, 1887, and of January 7, 1888, he quoted further figures of cost with keen appreciation. In the first of these articles he gives the data for 28 days in October, 1887. They show that 3443 tons of ore were treated in the mill at a cost

	Stoping per load		Tramming 4874 loads	Milling 4874 loads per load	Boarding-house per man per day	Superintendent and general expense	Total
	Cuts 4746 loads	Stopes 128 loads					
Miners	$0·046	$0·586	......	......	......	....	$ 292·05
Car-men	......	......	$0·033	......	......	....	161·00
R. B. men	......	......	......	$0·020	......	....	96·00
Blacksmith	0·004	0·127	......	0·008	......	....	73·75
Millmen	......	......	......	0·046	......	....	223·85
All other labor	0·023	0·813	......	......	$0·097	$100·00	346·10
Total labor	$0·073	$1·526	$0·033	$0·074	$0·097	$100·00	$1192·75
Iron and steel	......	......	......	$0·001	......	....	$ 8·38
General hardware	$0·001	$0·016	......	0·002	......	....	19·12
Oils and candles	......	0·037	$0·001	0·002	$0·004	....	24·47
Explosives	0·016	0·113	......	......	......	....	93·38
Boarding-house	......	......	......	......	0·362	....	123·71
Mill	......	......	......	0·043	......	....	208·30
Shoes and dies	......	......	......	0·019	......	....	92·36
Timber and lagging	0·001	0·094	......	......	0·010	....	19·50
Hay and grain	......	......	0·002	......	......	....	10·15
General expense	......	......	......	......	......	$ 2·10	2·10
Total supplies	$0·018	$0·260	$0·003	$0·067	$0·376	$ 2·10	$ 601·47
Total expense	$0·091	$1·786	$0·036	$0·141	$0·473	$102·10	$1794·22

of 23·9 cents, of which 13·3 cents was for labor and 10·6 cents was for supplies. The mining cost was 34·6 cents, of which 30·4 cents went for labor and 4·2 cents for supplies. The bullion produced was worth $3138·55, and the total expenses were $2015·04, so that a profit of $1123·51 was made on ore containing 91 cents' worth of gold per ton, the total cost being

only 58·5 cents per ton. In the next month, November, 4047 tons of ore were mined and milled, the total yield being $2644·57 and the total cost $2120·27, so that the profit was $524·30. The mining expense was 31·4 cents per ton and the milling only 20·8 cents, so that the total cost was 52·2 cents, as against a yield of 65 cents per ton.

The records of the Spanish mine were destroyed in the San Francisco fire of 1906, but, fortunately, the figures for another month, namely, June 1899, were preserved in a notebook, as tabulated on the page opposite.

The "load" was equivalent to a ton. These costs as detailed above include the salary of the superintendent and the general expenses, but they exclude expenditure at the boarding-house, because this was covered by a charge of a dollar per day for board and lodging, as paid by the men on the pay-roll. The total cost, as will be noted, amounted to 37 cents per ton, to which must be added the expense of the shoes and dies used in milling; this item is not given in the notebook, but it can be stated as not more than 5 cents, so that the total cost amounted to 42 cents per ton. This serves to show that the low costs of 1887 were not a mere flash in the pan; on the contrary, the operations were continuous in economic character from 1886 to 1900.

Subsequently Mr. Bradley became consulting engineer and president of the Alaska Treadwell Gold Mining Company, and at the mines on Douglas island, Alaska, he made a new record on a much bigger scale. In obtaining such satisfactory results he was aided by the successive resident managers, Joseph MacDonald, Robert A. Kinzie, and Philip R. Bradley.

In the year 1913 the Alaska Treadwell company mined 886,057 tons of ore at a cost of 82·71 cents per ton, including development; this output was milled at a cost of 24·76 cents per ton, and a total operating cost of $1·21 per ton, to which 7 cents per ton was added for dwellings and construction, making a total cost of $1·28 per ton, inclusive of taxes and office expenses at Paris, London, and San Francisco. The

net profit was $1·38 per ton, and the total profit, $1,448,438. Up to that time the total tonnage treated had been 13,867,789; the gold yield, $33,964,625; the profit, $15,674,258; and the dividends, $13,785,000.

The favorable factors that facilitated this performance were various: a large lode, which was stoped for an average width of 125 feet; no timbering was required, yet the ground broke so well that 30 tons were broken per machine-shift; the larger fragments required block-holing, or 'bulldozing', but this could be done effectively, because the gold-bearing rock broke easily into large slabs. In the mill the ore could be readily pulverized by stamps, at the rate of 4·8 tons per stamp per diem. Half of the gold in the ore was free, that is, it could be saved by amalgamation on silvered copper plates; the other half of the gold was collected in the 2 per cent of pyritic concentrate, from which later it was extracted by cyanidation. The position of the mine, at tide-water, permitted marine transport for machinery and supplies; the seasonal variations in the weather were not such as to handicap operations, and an adequate force of intelligent workmen was always available, thanks partly to proper housing and considerate management.

The success of this group of mines on Douglas island prompted plans for starting similar large-scale operations on the gold lode upon the mainland opposite, where a potential orebody 4 miles long and as much as 1000 feet wide had been outlined in the workings of the Ebner, Alaska Juneau, and Perseverance mines. Each of them had been exploited with moderate success for a gold ore of medium grade, that is, from $2 to $4 per ton, after sorting; and it seemed likely that they would prove even more profitable if worked on a much larger scale such as would permit of the beneficiation of their low-grade ore, that is, an ore comparable with that being treated so successfully by the Treadwell companies.

The Ebner was worked for 15 years by a man of that name, who proved the existence of large reserves of putative ore yielding $1·80 per ton for a width of 60 feet. An adit, to cut

the lode at a depth of 1200 feet, was started in 1913 by the engineers of the United States Smelting & Refining Company, with a view to developing enough ore to justify milling operations on a big scale. This undertaking was dropped in 1917, because no orebodies of adequate dimensions were disclosed.

The Perseverance mine was acquired by Joseph T. Gilbert, of Gilbertsville, New York, in 1895. He and his partners erected a ten-stamp mill and a wire-rope tramway, for the purpose of testing the ore broken from the outcrop. This selected ore yielded \$4 per ton. The desultory operations came to an abrupt end when, in 1899, a snowslide destroyed both the mill and the tramway.* A year later Charles Pearce, who worked as foreman in the Treadwell mine, happened to meet Colonel W. J. Sutherland, a promoter, to whom he spoke concerning the Perseverance mine. Whereupon the Colonel took the business in hand and drove an adit 2400 feet long to tap the lode at 1300 feet, on its dip of 73 degrees, below the outcrop. This adit, known as the Alexander tunnel, intersected 70 feet of lode assaying \$2·40 per ton. In 1904 Sutherland met Arthur L. Pearse, an English mining engineer of good standing, in London, and engaged him to examine the mine, with a view to placing £100,000 in bonds with Achille Adam, of Paris. Pearse reported favorably, but Adam and Sutherland failed to agree on terms. In 1905 the firm of John Taylor & Sons, long and honorably established in London, sent J. H. Clemes to examine the mine, but he declined to confirm Pearse's appraisal of its potential value, because at that time an outcrop 4000 feet long and a point in an adit 1300 feet below represented the only evidence on which an estimate of 10,000,000 tons of ore had been predicated. This, to a conservative engineer, seemed much too expansive. However, the Colonel raised some money in London, and, aided by Gilbert, proceeded to the building of a 50-stamp mill, which was completed in 1906, and served to provide a precarious profit. A yield of \$1·90 per ton was obtained at a working

* T. A. Rickard, editorial, *The Mining Magazine*, London, March, 1914.

cost of \$1·20 per ton. Another unit of 50 stamps was added in the following year, 1907, and the increased milling capacity reduced the working cost to 93 cents, on a yield of \$1·80, per ton. This work was done in the name of the Alaska Consolidated, which was the holding company for the Perseverance Mining Company, of New York. For five years this company operated on a narrow margin, the working profit at the mine

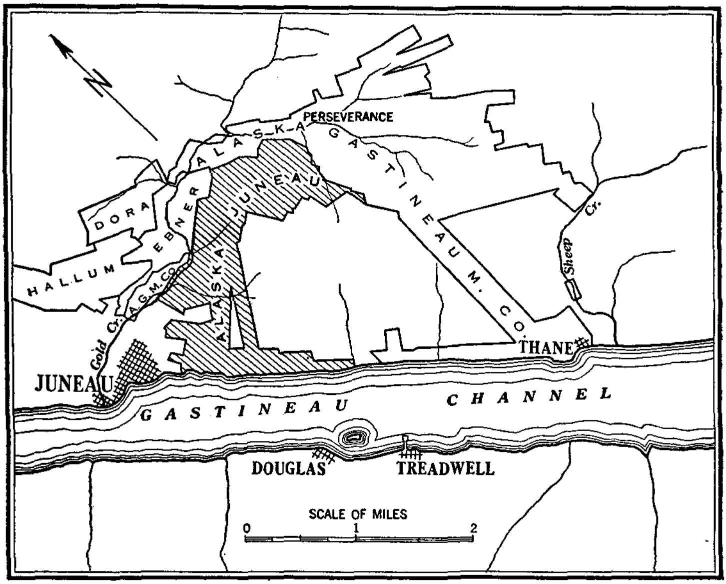


Fig. 5.—Map of the Juneau mines.

being absorbed in new equipment, London expenses, and frequent litigation. In 1911 Colonel Sutherland died. He owed his title to having been on the staff of a Cuban governor, and he had most of the characteristics of the typical promoter of the nineteenth century: expansive and expensive, florid and flamboyant, persuasive and persistent. Just before his death serious litigation had been started in Alaska on the initiative of Louis Shackleford, who had quarreled with the Colonel over

a game of poker, and had vowed to get even. He held apex rights by means of a claim called the Groundhog, which covered part of the outcrop, and he controlled sundry other claims on Sheep creek along the strike of the lode. Therefore Shackleford, with B. L. Thane, a local mining engineer, acquired the ground on which the tailing from the Perseverance mill discharged and thereby held Sutherland in a cleft stick. On the death of Sutherland, the other two, with Wendel P. Hammon, of San Francisco, approached the English shareholders with a view to a compromise and an eventual consolidation of the conflicting interests. This was finally accomplished in 1912, when the Alaska Gastineau Gold Mining Company was registered in New York for the purpose of acquiring the various Perseverance properties. Thereupon bonds were issued through Hayden, Stone & Company, of New York, for providing a working capital of $1,250,000. As soon as this had been accomplished, the promoters sent D. C. Jackling and A. F. Holden to examine the mine. They reported favorably, and recommended the provision of $4,500,000 for development and equipment, the latter to include a mill of 6000 tons daily capacity and a hydro-electric power-plant. It is evident that confident expectations were entertained and that operations on a magnificent scale were planned; but this was no half-baked affair, it was under the guidance of highly competent mining engineers. The required capital was raised by issuing 614,700 shares at $10, the remaining 135,300 shares, out of a total authorized capital of 750,000 shares of $10 each, being held in reserve for general purposes and to acquire the outstanding minority stocks of the two original constituent companies. This issue was made in July 1912, $5 per share being paid on allotment and $5 a year later. In 1914 the shares were quoted at $24.

The scheme outlined by the management was an enlargement of that suggested originally by Pearse. His first milling unit was to have a capacity of 2000 tons daily; Jackling and Holden proposed to start with 6000 tons daily. Pearse esti-

mated a stoping-width of 60 feet, averaging \$2·20 per ton, to be worked at a cost of \$1·25 per ton; his successors expected to stope an average width of 70 feet, containing \$1·50 in gold per ton, at a cost of 75 cents per ton. This later estimate was not based upon ordinary sampling, which in a lode of such size and grade, and with so few openings, was deemed impracticable, but upon the yield of the 600,000 tons that had been taken from three large stopes. The plans for development included the driving of an adit in the lode from Sheep creek at an average depth of 2200 feet below the outcrop, or about 700 feet below the old workings. At that time, in 1912, it was assumed that 50,000,000 tons of ore were "definitely indicated", and on this basis the property was deemed a "bargain" at \$12,000,000, provided the necessary working capital became available. It was expected that the ore, as broken in the mine, without sorting, would yield \$1·50 per ton in the mill. This expectation was based upon the work done previously in the Perseverance mine by a competent superintendent, J. R. Mitchell, a Cornishman, who had applied the caving system successfully, and had proved thereby that the ore could be broken at the rate of about 100 tons per machine-drill shift. It was anticipated that the cost of mining, plus development,

	1915	1916	1917	1918
Ore treated, tons	1,115,294	1,892,788	2,240,346	1,285,445
Average value	\$1·16	\$1·19	\$1·11	\$1·09
Recovery, per cent	81·06	81·33	81·32	81·10
Cost of mining	\$0·31	\$0·38	\$0·42	\$0·51
Cost of milling	0·31	0·27	0·26	0·33
Total cost	\$0·71	\$0·75	\$0·77	\$0·90

could be reduced to 24 cents, as against 72 cents in the Treadwell mines.

The mill started to work in February, 1915, by which time it was estimated officially that between 75,000,000 and 100,-

000,000 tons of ore having a recoverable value of \$1·50 per ton had been proved.* In March the mill treated 40,000 tons, the tailing assaying 30 cents from a feed of \$1·85 per ton. During the four years 1915–1918 the results were as shown on the page opposite.

The financial sequel is told best with the arid eloquence of statistics.†

	1915	1916	1917	1918
Revenue	\$1,046,104	\$1,837,291	\$2,009,632	\$1,136,223
Operating charges	794,256	1,423,260	1,724,474	1,233,168
Profit or loss	+251,848	+414,031	+285,158	−96,945
Interest paid	....	217,747	228,552	219,685
Net income	....	112,834	42,275	−336,250

In April, 1915, the shares sold at \$40·75, and the bonds (two issues each of \$1,500,000 at 6 per cent) sold at \$160, together equal to a valuation of over \$35,000,000. In 1922 the loss was \$144,538. Then silence.

The milling practice was most ingenious, and was based upon an application of the methods applied so successfully to the concentration of low-grade copper ores, in which field the engineers of the company had special and successful experience. The conventional processes of amalgamation and cyanidation were discarded completely. The crushing was done by gyratory breakers, supplemented by jaw-breakers of unusual size.‡ The ore was then conveyed to rolls, supplemented by more rolls, with an intermediate sizing upon impact screens. This product passed over tables of the Garfield and Wilfley type, followed by Richards-Janney classifiers, the coarse product from which went to tube-mills, while the fine passed to more Garfield and Wilfley tables. The final products consisted of

* *Mining and Scientific Press*, Vol. CX, p. 781; 1915.

† *Mining and Scientific Press*, Vol. CXVIII, p. 685; 1919.

‡ L. E. Spray, 'The Alaska Gastineau Mill', *Mining and Scientific Press*, Vol. CX, p. 612; 1915.

several classes of concentrate, all of which were shipped to the Selby smelter, near San Francisco.

The failure of the Gastineau enterprise was due to an optimistic estimate of the grade of the prospective output of the mine when worked on a magnified scale, and also to an unexpected dilution of the ore as it came from the stopes. In the official report for 1914, reference was made to "the known continuous and uniform nature of the ore deposits",* but such a statement was not warranted by previous experience in either the Gastineau or the Juneau mines. The assumption, which seems to have underlain the estimates of the promoters, that the 600,000 tons mined under Mitchell's superintendency could be regarded as a fair sample, was fallacious. Every miner selects his ore and selects the places where he is to obtain it; mining is essentially a selective process; and Mitchell, an experienced Cornishman, was a sagacious miner. This fact was not sufficiently appreciated. Moreover, it was expected, under the modified caving system adopted at the Gastineau, that the rock broken would be restricted to specific parts of the lode, but this is not what happened; in consequence there was a dilution, by inclusion of barren rock, that lowered the grade of the output, and thereby vitiated the estimates. Another, perhaps minor, factor was the wetting of the ore. The average annual precipitation, as rain and snow, at Juneau is 85 inches, and along the crest of the mountains, where the outcrop of the lode extends, the precipitation is 130 inches. When the ground became fractured by the vigorous mining operations underground the seepage from the surface moistened the ore, which, in this unsuitable condition, went to the dry-crushing mill, and therefore caused difficulties in the treatment. In other words, a dry-crushing mill of the copper-concentration type was not suited to a wet and sticky ore. The failure of the Gastineau enterprise was due, it is fair to conclude, to insufficient appreciation of previous local experience on the part of engineers of distinguished ability, as demon-

* *Engineering and Mining Journal*, p. 63, July 10, 1915.

strated in their own special field of copper-mining. However, as Mr. Jackling is said to have remarked, one can not pick a winner every time.

Meanwhile an enterprise of similar character was being incubated at the Alaska Juneau, which lies between the Perseverance and the Ebner mines. For many years before 1915 the Juneau was treated as one of the Treadwell group, although separated by the strait called Gastineau Channel, because friendly stockholding interests were represented by interlocking managements. F. W. Bradley was president and consulting engineer of the Treadwell group, and president also of the Juneau company, with Robert A. Kinzie as resident manager for both mines. The Juneau was owned by a private company that included among its principal shareholders Wernher, Beit & Company, the South African promoters and financiers, also the old Exploration Company, of London, with Hamilton Smith, its consulting engineer, also his partner H. C. Perkins, and the estate of Thomas Mein, who at one time was manager of the Treadwell mines, and subsequently became manager of the Robinson mine at Johannesburg, in the Transvaal. Up to 1915 this company had paid $55,000 in dividends. From 1897 to 1900 inclusive a total output of 72,321 tons was treated, after careful sorting, in a 30-stamp mill. The yield averaged $4·10 in free gold, recovered by amalgamation. No concentrate was made. During the subsequent nine years, from 1901 to 1909, an output of 181,436 tons was treated in the same mill for an average yield of $1·45 per ton, also as free gold, by amalgamation. The decreased return during this later period was caused by a change of method, careful sorting giving way to the selection of blocks of ground in mining, supplemented by rough sorting before milling. Between 1903 and 1905 two adits, 400 and 500 feet respectively below the open-cuts from which the previous output had come, were driven to, and through, the lode. Slices from the sides of these new workings were tested in a five-stamp mill. This sampling indicated a width of 343 feet of ore yielding at the

rate of 90 cents in free gold in the upper adit and 570 feet of ore of an equal gold content in the lower adit, a part of which, 173 feet long, showed $1·22 per ton. In August, 1910, F. W. Bradley suggested that $500,000 be spent in driving an adit 5700 feet long to cut the lode 900 feet below the upper workings; at the same time he advised the building of a 100-stamp mill, a power-plant, and such other equipment as might be required to test the feasibility of exploiting this immense low-grade gold deposit on an adequate scale. Moreover, he offered to complete 5000 feet of the proposed adit for 50 shares of the company's stock per linear foot, that is, 250,000 shares for the whole 5000 feet of adit. In 1903 the Juneau company's capital had been increased from 500,000 to 750,000 shares, and the additional 250,000 shares happened to be intact. Thus the arrangement with Bradley was facilitated. Upon the completion of the adit he was to equip the mine as planned, to a productive capacity of 23,000 tons per month, and in return he was to receive 250,000 shares more, the capital of the company being increased by that much, to 1,000,000 shares. Thus he was to become the owner of half the stock, which, together with his former small holding, would give him the control. In December, 1910, an agreement embodying these terms was consummated by Perkins and accepted by all the stockholders. Thereupon Bradley alloted one third of his interest in his contract to Ogden Mills, chief shareholder (in succession to his father) in the Treadwell companies, and another third to the San Francisco Exploration Company, a partnership consisting of J. H. Mackenzie, M. L. Requa, and Bradley himself. Later the stock held by Wernher, Beit & Company was purchased by W. H. Crocker.

The adit was driven in due course successfully to completion in 1913. The lode, where it was cut at this level, averaged $2 per ton over a width of 500 feet; whereupon Bradley, by averaging the yield of the old workings overhead with that of the sampling at the adit-level, estimated a yield of $1·45, to be won at a cost of 80 cents, per ton. The sampling had been

done carefully, in the ordinary way, with moil and hammer. The estimate of cost was based upon his experience at the Treadwell, together with such mining and milling as he had supervised at the Juneau itself. By combining the caving system, already used in the Perseverance mine by Mitchell, with the shrinkage stoping method used in the Treadwell mines, he expected to obtain 100 tons of broken ore per machine-drill shift as against an average of 30 tons in the mines on Douglas island.* He expected that whereas sorting of 4½ to 1 had yielded an average of \$4·10 during four years, and whereas selection of ground and rough sorting in the ratio of 1·6 to 1 had yielded an average of \$2·70 during nine years, it would be feasible to obtain an average yield of \$1·45 by sorting 3 to 1 henceforth when mining on a larger scale underground.

The successful flotation of the Alaska Gastineau and the good reports from that mine caused Bradley's associates to insist upon a public flotation of the Juneau in March 1915. Shortly thereafter the capital of the Alaska Juneau Gold Mining Company was increased to \$15,000,000 in \$10 shares. At that time a pilot-mill of 50 stamps, erected on the shore of Gastineau Channel, showed that the run-of-mine averaged \$1·50 per ton, which meant \$3 per ton for sorted ore. A report† was issued jointly by Bradley and Mackenzie shortly after the flotation of the company; in this report they stated that there was available 80 to 100 million tons of ore that after sorting should have an average assay-value of \$2 and should yield a net profit of 70 cents to \$1 per ton. A block of 400,000 shares at \$10 was underwritten and sold at par by a syndicate headed by Bernard M. Baruch, who took pains to emphasize the conservative character of the technical estimates, whereupon the shares rose to \$15. The pilot-mill of 50 stamps, which had gone to work in 1914, gave results as shown on the next page.

* F. W. Bradley, *Mining and Scientific Press*, Vol. CVII, p. 882; 1913.
† *Mining and Scientific Press*, Vol. CXI, p. 917; 1915.

Year	Tons	Gold, assay-value	Yield		Tailing
			Gold	Concentrate	
1914	60,026	$1·43	0·91	$0·25	0·27
1915	179,892	1·48	0·69	0·48	0·29
1916	180,113	0·91	0·39	0·61	0·26

In the report for 1916 Mr. Bradley stated that up to date, including the early milling in Silver Bow basin, the mine had yielded 742,220 tons having an average assay-value of $1·93 per ton for gold alone, and that the large-scale milling of the future should be done on an ore containing $1 per ton in gold, silver, lead, and zinc. The cost was estimated not to exceed 50 cents per ton, having in view a capacity of 10,000 to 12,000 tons per day in the new mill. This may be compared with the forecast, three years earlier, of $1·45 in yield and 80 cents in cost. Evidently the expectations on which the Juneau enterprise was started had begun to suffer a discounting, but most of the estimated margin of profit had survived and the tonnage of ore assured was now so great as to indicate a winning by no means unsatisfactory. Then a serious blunder was made. Early in 1915, Bradley became ill, and in June he went to Honolulu to recuperate. Meanwhile one of the directors had issued a circular, unwarrantably optimistic, and shortly before Bradley's departure the directors sanctioned the erection of a mill of 8000 tons capacity. This was done under the direction of Mackenzie, who had become consulting engineer in Bradley's absence.* The mill was ready to start in March, 1917, and in the May following Mackenzie relinquished his duties as consulting engineer. The mill proved a failure; the lining of the ball-mills was defective; the passing of the ore from the gyratory crushers direct to ball-mills of a type untried outside cement practice failed to produce the

* J. H. Mackenzie, *Mining and Scientific Press*, Vol. CXVI, p. 323; 1918.

desired pulverization; the capacity of the plant was only 1200 tons per day in May and 3274 in December, the highest being 3833 per day in November, or considerably less than half of what was expected. The cost of milling during the last four months of 1917 was 40 cents per ton mined, the total cost was 70 cents, and the yield was 75 per cent of an assay-value of 82 cents, so that a loss of 8 cents per ton had to be faced, the little lead and silver that were recovered being absorbed by freight and treatment charges on the concentrate. The average gold-assay value of the mill-feed for the year 1917 was 86 cents. The operating loss incurred after the mill started was $144,940 at the end of January, 1918, by which time the company was indebted to the amount of $1,000,000.

The enterprise seemed about to end in a fiasco, and Mr. Bradley might easily have saved himself a great deal of the worry that had suddenly come upon him in consequence of the unwise policy of his associates, who built a mill that ignored the experience acquired in the operation of the pilot-plant and of other mills in the district. However, he felt under obligation to the shareholders, most of whom had bought stock on account of their confidence in his skill and integrity, and he had a certain not unreasonable urge to persist in proving that his plans, carried out by him, would come to profitable fruition. He was assisted loyally by his brother, Philip R. Bradley, who was resident manager of the mine from 1914 to 1920, and consulting engineer afterward.

The new mill had been built without providing facilities for sorting, whereas the experiments in the pilot-mill and all previous plans had been based upon the expectation that sorting would be practised as an integral part of the operations. Here note may be made of the fact that all the early milling at the Juneau during a long series of years included some measure of selection of ore and the sorting of it after it had been mined; and it was the proper sorting of the ore before grinding that in the end turned failure into success. The mill had to be altered radically, and further experimental work

had to be conducted before the plant could be completed. It was a difficult task. Operations continued to be unprofitable, of course, and the indebtedness increased rapidly, for this is

PILOT-MILL

Year	Number of days in operation	Tons mined per day	Per ton milled		
			Cost of milling	Gold assay-value	Gold recovered
1914	311	201	$0·4473	$1·32	$1·06
1915	363	495	0·3917	1·33	1·04
1916	364	495	0·4953	0·94	0·64
NEW MILL					
1917	274	2,472	0·7171	0·86	0·64
1918	363	1,631	0·6762	0·92	0·73
1919	363	1,909	0·5608	0·99	0·72
NEW MILL UNDER RECONSTRUCTION					
1920	364	2,590	0·4463	1·08	0·78
1921	363	4,445	0·3554	0·86	0·60
1922	361	6,400	0·2613	0·81	0·56
1923	361	6,860	0·2662	0·81	0·58
1924	362	8,476	0·2512	0·87	0·62
1925	362	9,618	0·2504	0·85	0·58
NEW MILL COMPLETED					
1926	362	10,579	0·2154	0·75	0·50
1927	362	11,790	0·2257	0·77	0·55
1928	363	10,243	0·2285	1·11	0·84
1929	362	10,598	0·2319	1·12	0·89
1930	363	10,811	0·2269	1·11	0·86

one of the penalties of large-scale operations when they miscarry. Mr. Bradley personally advanced the necessary funds, until the amount became too burdensome, whereupon an issue of bonds for $3,500,000 was authorized on March 15, 1919.

The response at first was restricted to two stockholders, each for $500, in consequence of which he himself subscribed for the major portion of these bonds, of which $1,894,000 was issued ultimately. By that time all the defects of the mill had become apparent and steps were taken to correct them, the principal change being the addition of sorting-belts, together with the equipment required for the disposal of the rejected rock. Again let us avail ourselves of the arid eloquence of statistics as recorded on the opposite page.

The 10 years, 1917–1927, constituted a period of severe strain and courageous effort; then came the assurance of success. Slowly the capacity of the mill was increased to a maximum of 14,000 tons per diem, but this was too severe on the equipment, and it was decided that 10,000 tons was the tonnage best suited to the plant. Slowly a profit was won and in due course the bonds were retired, the extinction of all indebtedness being finally achieved at the end of 1930, by which time the sum of $3,378,586 had been liquidated. In December of 1930 there was mined and trammed to the mill 325,990 tons, the yield from which was 97·55 cents in gold, besides 1·53 cents in lead and silver, per ton. The cost of mining and tramming was 28·68 cents per ton; of milling, 19·94; of other operating costs, 2·15; and of head-office expenses, 0·77 cent. Thus the total cost was 51·54 cents and the operating profit, 47·54 cents per ton, or a total profit of $155,000 for the month. A dividend of 10 cents per share per quarter was declared, thereby emphasizing the emergence of the enterprise from gloom into sunlight.

The following description outlines the operations of the mill. The basic principle of the treatment is to reject and remove the barren portion of the mine output as quickly as possible. The gold in the ore is intimately associated with galena in quartz, which is distributed through the rock (slate and gabbro) in the form of veinlets and irregular masses. After the mine output has been broken to a minimum thickness of ten inches, it is easy to pick out the quartz and the

rock showing any quartz, these being dropped into the bowl of a gyratory crusher. The clean slate and gabbro remain on the belt and proceed to the waste dump. Out of 10,000 tons brought by tram from the mine, 4100 tons is rejected by sorting on belts, where the picking is facilitated by spraying the material as it goes onto the belt after it has been crushed. Sizing by means of impact screens is followed by further sorting, whereby 1450 tons additional are rejected. Fine grinding in rolls and ball-mills is followed by tanks and tables that together eliminate a further 4250 tons as tailing; finally another 193 tons is removed by flotation; so that altogether 9993 tons of waste material is rejected, leaving only 7 tons of lead concentrate, in which the gold, with a little silver, is collected. The coarse gold goes into the concentrate, and is collected along the extended central riffle of a Wilfley cleaning-table, from which it drops into a bucket, enclosed in a steel tank, to prevent robbery. From this container the gold, with some black sand, is removed to a barrel, in which it is recovered by amalgamation. This last process requires only two hours of one man's time daily. Thus 80 per cent of the total gold recovery is effected; the other 20 per cent remains in the galena concentrate, seven tons daily, which is shipped to the Bunker Hill smelter in Idaho.

The various estimates for the Juneau predicted (1) a yield of $1·45 to be won at a cost of 80 cents, (2) an assay-value of $2 to yield a profit of 70 cents to $1 per ton, and (3) a $1 ore that was to be treated for 50 cents per ton. This last estimate was the one made by Mr. Bradley in 1916; and it has been justified. In the Juneau estimates, as in those of the Gastineau, a factor of error was introduced by the omission to recognize the effect of faults and of a variant richness of the parts of the lode, in the form of ore-shoots, whereby the output did not have the uniformity of character and content that had been anticipated, although at the Juneau the consequent discrepancy was not as critical as it was in the case of the neighboring mining venture. A shaft that was sunk recently

200 feet below the adit has cut into ore worth $4·40 per ton. This is not a suggestion of enrichment in depth, but a confirmation of the belief that the lode is differentiated by the occurrence of ore-shoots. The adit penetrated $2 ore, as has been mentioned, but the stopes immediately overhead ran into low-grade stuff, so that possibly the shaft may have entered an ore-shoot, the top of which was cut by the adit.

The Juneau today is believed to have enough ore in reserve to supply the 3,800,000 tons per annum required at the present rate of exploitation for at least 20 years. Therefore it is probable that in the years to come the present record for low-cost mining and milling will be bettered, but, such as it is, the performance constitutes a notable achievement.

CHAPTER V

THE COMSTOCK LODE

The finding of gold, in enriching quantity, along the streams that issued from the western foothills of the Sierra Nevada was the prelude not only to the birth of an organized mining industry in California but to the intensive exploration of the entire Pacific slope; it presaged the feverish exploitation of the mineral resources that the ubiquitous prospector soon uncovered all over our western domain. At first when this migration began, as typified by the rush of 1849, there was no time to examine the signs of ore that were to be detected along the track of adventure, and, it must be added, not many in that motley crowd of gold-seekers were qualified to interpret the signs if they had lingered to look at them. Such intelligent curiosity as a few of them possessed was directed to the finding of gold chiefly, if not exclusively; and their good sense in this respect can not be impugned, because in a new and remote country the less valuable metals and minerals are unlikely to be worth the winning.

Many of those that came to California crossed the alkaline wastes and sagebrush prairies that extend between the Great Salt Lake and the ramparts of the snow-clad Sierra; when coming overland they found it convenient to halt on the eastern slope and to pitch their camp in the valley of the Carson river before they began the tedious ascent of the mountains and the final entry into the land of gold. One of the trails most used by these immigrants followed the Carson river to the mountain meadows south of Lake Tahoe and then descended among the pine-woods of Placerville, where they went to work with pan and shovel in the gold-bearing streams

tributary to the American river, the *Rio de los Americanos* of the Mexicans in California. The Carson valley became a resting-place on the road; it was an oasis in their desert pilgrimage. That migration, like an army, had many camp-followers; it included all sorts and conditions of men and women, and children as well. Among others a party of Mormons, led by Thomas Orr, came westward from Salt Lake City in 1849; one of them, William Prouse, of Cornish origin, used a milk-pan to wash the gravel in a little creek that entered the Carson river from the west, where the hamlet of Dayton now stands. The date was May 15, 1849. Prouse found a few specks of gold in his pan, but they gave no promise of such riches as were anticipated across the mountains in California; therefore he and his Mormon friends decided to move forward to the Eldorado in the west. They were delayed, however, by a heavy fall of snow and remained in the Carson valley for three weeks, during which John Orr, the son of the Mormon leader, and others of the party returned to the gulch in which Prouse had prospected. They found a little more gold and also some pieces of quartz that contained gold, but they lacked the tools and provisions required for a proper campaign, and, being eager to proceed to California, they abandoned the diggings as soon as the trail across the mountains was sufficiently free from snow.* The gravel was not rich enough to beguile these prospectors from the larger lure that lay across the mountain ramparts separating California from the territory that was then part of Utah, and is now Nevada. The creek where Prouse prospected became known as Gold canyon; it was the door to one of the treasure-vaults of the world, the Comstock lode; but no one surmised the connection.

Meanwhile others had come into this valley, and the placer diggings attracted many of them. Among these a party of Mexican peons led by Ignacio Paredés, from Alamos, in Sonora, tried to work the gravel with their *bateas*, or wooden

* Eliot Lord, 'Comstock Mining and Miners', U. S. Geol. Survey, p. 12; 1883.

bowls.* The creek had dwindled to a mere thread of water, so that ordinary gold-washing was impracticable; therefore the Mexicans separated the gold by dry-blowing, a method that, like the winnowing of grain from chaff, employs air as the medium for recovering the particles of gold from the silt of the river-bed. A few weeks of this work sufficed for this party also, because supplies were scanty and the gold winnings were meagre.

Two years later, in 1851, John Reese and some other Mormon pioneers started little farms in the Carson valley and found a ready market for their produce—crops and cattle—among the miners, of whom there were from 20 to 130 at work, according to the season, in Gold canyon. Their earnings averaged $5 per day, and the supplies now obtainable from the ranches made life more tolerable. In 1852 a settlement, named Johntown, was established in Gold canyon at a place that was four miles above the Carson river. At the junction itself were the huts of the Chinese, who, as early as 1856, were at work in their patient and careful way, picking up the crumbs, as it were, that the Caucasian dropped. This hamlet was known as Chinatown, until, at a later date, it was re-named Dayton.

Sluice-boxes and rockers became numerous as the placer miners slowly worked their way up the gulches. About $100,000 worth of gold was gathered annually until 1857, by which time the gravel in the lower parts of the canyons and in the bars of the Carson river had been pretty well exhausted. They did not prospect on the upper slopes, nor did they have any idea of the wealth that lay in the ground above them. Some of the gold they washed out of the higher diggings was pale and they were paid only $12 per ounce for it, instead of the usual price of $18 for placer gold. The admixture with silver did not mean anything to them; they were perplexed, but not inquisitive. It is said that in 1853 some of the gulch-miners hired a Mexican, who tried to tell them that there was plenty

* Charles H. Shinn, 'The Story of the Mine', p. 16; 1903.

of silver on the mountain overlooking their placer workings. He could not speak English, so he said "*Bueno*", and pointed to the peaks above the canyon; then, waving his hand as if to include the rocky slope, he exclaimed earnestly "*Mucha plata! Mucha plata!*". They did not understand what he meant until long afterward when the memory of his words and gestures had been illumined by the light of later events.* He left in three days, and played no further part in the melodrama of the Comstock. This story has merit, but it is not at all convincing, because not even a keen-eyed Mexican familiar with silver minerals could have found any along the Comstock outcrop, although he might have seen some elsewhere, not far from Gold canyon, as will develop in the course of this history.

The men in Gold canyon indeed were a shiftless and a sodden lot, but not all of them; among the illiterate mob that found slim pickings in the gulch were two brothers named Grosch, born in 1824 and 1826 respectively, the sons of a Unitarian clergyman in Pennsylvania.† In common with other young men they were stirred by the news of the discovery of gold in California, and sailed from Philadelphia to Tampico in February 1849. They crossed Mexico and reached San Blas, on the Pacific coast, after undergoing many hardships. At San Blas they went aboard a bark that took them to San Francisco, where they arrived in August, just six months from their start. In 1850 they were at the Eldorado diggings; in 1853 they crossed the Sierra Nevada and joined the miners in Gold canyon. Hosea Grosch and Allen Grosch were intelligent and observant young men; they had some books, probably of a technical character, and they had also some assaying apparatus of a crude kind, probably made by themselves.

* Dan De Quille [William Wright], 'History of the Big Bonanza', p. 39; 1877.

† S. H. Marlette, *Annual Report* of the Surveyor General of Nevada, 1865, and Dan De Quille, *Engineering and Mining Journal*, Vol. LIII, p. 254; 1892.

They were quiet and reticent, and owing to their aloofness from the other diggers they were regarded as a mysterious pair. Soon after their arrival they built a stone hut at the base of Grizzly hill in American ravine, at the south end of the settlement that became Silver City. Although the Grosch brothers were fairly successful in their gold-washing, they appear to have devoted most of their energies to a search for silver ore. In 1856 Hosea wrote to his father telling him that they had found some silver: "it resembles sheet-lead broken very fine, and lead the miners suppose it to be . . . other ore of silver we think we have found in the canyon, and a rock called *black rock*, very abundant, we think contains silver". The placer miners often complained of a heavy mineral, which they named 'black iron' and 'blue stuff', as it clung to the bottoms of their sluice-boxes and clogged their riffles. Some of this when found at a later date may have been a sulphide of silver, such as the mineral argentite, but other pieces probably were only the "black rock" mentioned by Hosea Grosch; this could not have been argentite or any ore rich in silver, otherwise they would have discovered the fact by their assaying. On the slope of Mount Davidson there is plenty of heavy ironstone, blackened by manganese oxide, such as will fit the references to "black rock". Later the young man informed his father that they had discovered "two veins of silver at the forks of Gold canyon . . . one of these veins is a perfect monster". A reference to cupellation indicates that they had a muffle-furnace. In 1857 Allen Grosch wrote to his father: "Our first assay was one-half ounce of rock; the result was $3500 of silver to the ton,* by hurried assay, which was altogether too much of a good thing . . . we assayed a small quantity of rock by cupellation from another vein. The result was $200 per ton. We have several other veins which

* This is said to be the first silver smelted in the United States west of the Rocky Mountains. In 1859 a party of Mormons found silver in the Panamint mountains, in southeastern California, and built a small furnace, by aid of which they produced some bullion.

are as yet untouched. We are very sanguine of ultimate success". Poor fellows! they were destined to utter failure.

We may pause here to enquire whether the brothers had found a part of the southern outcrop of the great Comstock lode. It is more than probable that the irony of fate was not so emphatic; it is likely that the rich samples about which they wrote to their father came from one or more of the small veins near Johntown, which was situated half a mile below the place that later became known as Silver City.† The Kossuth vein has been suggested as the probable source of their specimens; but this vein shows no silver in its croppings, and these were not such as to have attracted the young men of our story. It appears that they were at work at a distance of at least five miles eastward from the line of the Comstock lode. During the winter of 1861 William Wright, whose pen name was Dan De Quille (a writer for the 'Territorial Enterprise' and the author of a book on the early history of the Comstock), found the remnants of two furnaces, together with fragments of crucibles and cupels, at the foot of Grizzly hill after a heavy downpour of rain had washed away the piles of debris and exposed these mementoes of the Grosch brothers. Among them was a piece of galena, which closely resembled the ore of a vein known as the Red Lead, about half a mile west of this spot. The vein carried from $40 to $60 in silver at the surface, but this ore proved to be only a patch. Close to the remnants of the furnaces, Wright found a metal tube belonging probably to a canvas bellows.* We must note the fact that silver was not found anywhere along the surficial exposure of the Comstock lode; the quartz in the parts of the lode that project above the surface of the ground is usually uninviting to the prospector, it contains small inclusions of country-rock, and does not look like promising vein-matter. At Gold Hill, where the outcrop of the lode was decomposed, so that gold

† For this suggestion, and several others, the author is indebted to his friend Grant H. Smith, who is preparing a history of the Comstock mines.

* *Engineering and Mining Journal*, Vol. LIII, p. 254; 1892.

was discovered at grass-roots, the detritus was mistaken for a placer deposit and was located as such by the discoverers. In that locality the ore of silver sulphide was not found until the mine-workings had penetrated 25 feet or more beneath the surface, for example, in the Bowers, Plato, Eclipse, and Bacon properties. All the evidence therefore warrants the conclusion that the Grosch brothers did not discover the Comstock lode. In later years a group of enterprising persons tried to use the Grosch story for the purpose of extracting money from the owners of mines on the Comstock; the promoters of the scheme claimed 3750 feet of the best part of the lode. The Grosch Gold and Silver Mining Company was capitalized at $5,000,000, and afterward at $10,000,000, on which basis enough stock was sold to pay for a long, costly, and futile litigation, which yielded no information of historic value.

We return to our story. During the summer of 1857 the two brothers gained a livelihood, as they had done in previous years, by gold-washing in the canyon while at intervals they continued their prospecting for silver on the adjacent hillsides. They made no effort at actual mining, because they had no money, and they knew that to open up a mine, especially a silver mine, it was necessary, at that time and place, to have ample capital, for, as the Spanish proverb says, *Para trabajar una mina de plata se necesita una mina de oro:* it takes a gold mine to develop a silver mine. This Spanish reference is apropos, because the reader may wonder why they sought for silver rather than gold, as their fellow-miners were doing. The clue, I suggest, is to be found in the fact that they employed, or had working with them, a Mexican whom they called Frank, and he, probably, having seen some silver-mining in Mexico, had put the idea into their heads. Bancroft says that he was an experienced miner.*

Their placer claims gave them the means of subsistence, but the workings were so far from the stream that they had

* H. H. Bancroft, 'History of Nevada, Colorado, and Wyoming', p. 96; 1890.

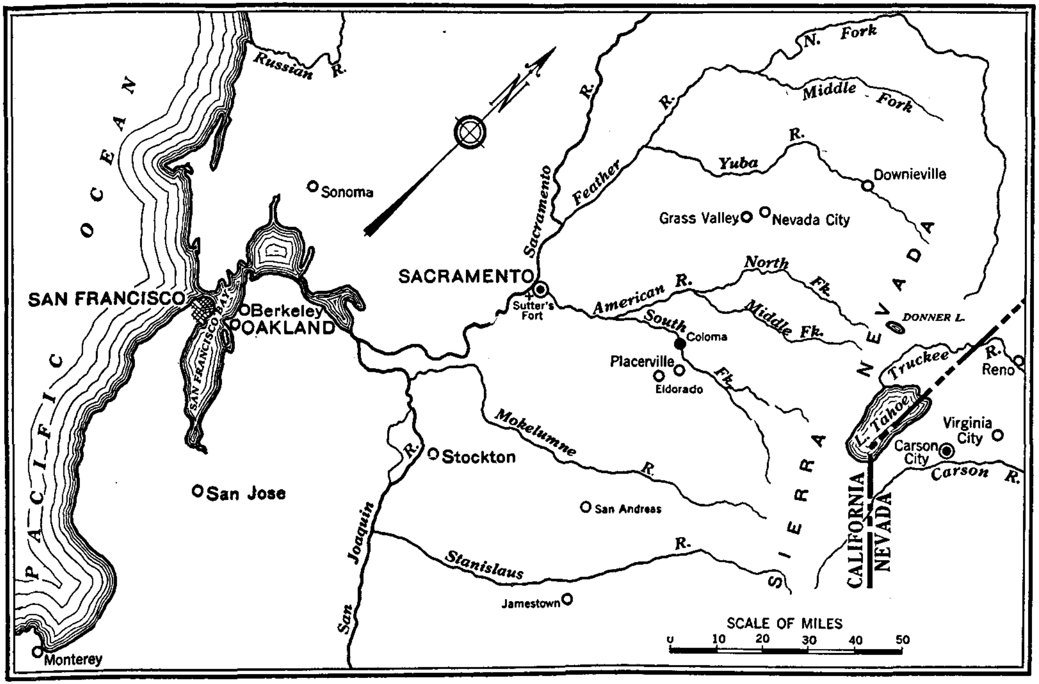


FIG. 6.—Map showing position of Virginia City relative to San Francisco.

to carry the detritus—not gravel—in sacks to the water; and this consumed so much time and energy that not much of either was left for their major enterprise, the search for silver. Therefore they did only enough gold-washing to pay for their food. It has been stated that in 1856 the brothers visited Eldorado, on the Californian side, and from there wrote to sundry friends in the Middle West from whom they obtained a little money for their undertaking, which they named the Utah Enterprise, because, it must be recalled, Gold canyon was then in western Utah. After returning to their diggings in 1857, they were promised further financial aid by George Brown, a cattle-man living in the Carson valley, but unfortunately soon afterward, on August 14, Brown was murdered. More misfortune was impending. Only five days later Hosea Grosch accidentally struck a pick into his foot and for lack of proper medical aid the wound became infected so that he died of lockjaw on September 2. Allen, much depressed by his brother's death, decided to go across the Sierra to the mining-camp of Volcano, where he intended to spend the winter. He was accompanied by Richard M. Bucke. They had delayed their start until the lateness of the season made the crossing of the mountains a dangerous adventure. For 11 days they struggled through the snow; indeed, they only just made their way through the drifts; and both were badly frost-bitten. Allen Grosch reached the journey's end ill and exhausted, soon to die; his papers were thrown aside when he and his companion were struggling in the snow. Bucke barely escaped with his life; one foot and one leg had to be amputated, and, after regaining some measure of strength, he betook himself on badly damaged stumps to Canada, where later at London, in Ontario, he became superintendent of the Dominion Insane Asylum. So the heavy hand of misfortune erased the investigations of these intelligent young men, and it was left for a drunken loafer and a shifty impostor to give their names to Virginia City and the Comstock lode.

A month after the death of Allen Grosch, the miners in Gold canyon organized a quartz (or lode) mining district at Johntown. They named the district Columbia. Among them was James Fennimore, or Finney, as he preferred to be known, a prospector during sober intervals. He was nicknamed 'Old Virginia', because he was born in that State. One day he was rambling along the hillside, near the spot where later the Ophir claim was located, when he espied a large outcrop of yellowish quartz. He found no sign of ore and made no attempt to test the ground, but, thinking, in a muddled way, that it might be a vein, he wrote a location notice on a slip of paper, which he hid among the loose stones. The date was February 22, 1858.* He did not record his claim, he made no effort to work it, and it proved of no consequence except as an excuse for a futile lawsuit. In the following winter Finney and three others, one of whom was John Bishop, were prospecting near the head of Gold canyon when they noticed a mound covered with snow, which they shoveled aside. Then Bishop took a panful of debris, from which he washed 15 cents' worth of gold. Afterward Finney examined the mound a little closer and found a gopher hole, at the mouth of which was some fine earth. This he panned, and it proved to be rich. Whereupon the four men staked four claims, each 400 by 50 feet, across the gulch, which happened to be along the line of the lode. They located the deposit as if it were placer ground. This was named Gold hill. It was the outcrop of the Comstock lode.

The question may be asked why the discovery of the great lode was so long delayed. One might suppose that the diggers in working their way up the gulches from the Carson river would have been led inevitably to the lode that by its erosion had enriched the placers. The truth is that the prospecting of the Grosch brothers and the less intelligent work of their companions in the early 'fifties had no relation to a discovery

* J. Ross Browne, 'Reports upon the Mineral Resources of the United States', p. 27; 1867.

of the Comstock. The gold in the lower gulches was derived from a series of little veins and stringers that abounded in the hillside above Johntown, and near the site of the later Silver City, three miles from the line of the Comstock lode. Much of their gold was obtained not from alluvium but from patches of detritus that they found not in the gulches but along the hillslopes. If this gold had been derived from the Comstock lode, they would have found more of it as they approached the source; instead, their diggings above Silver City became poorer, until they had to stop work, and then began to wander over the countryside in search of new diggings.

Gold hill is at the head of Gold canyon. After Finney and his friends had made their discovery, nearly all the residents of Johntown came thither; some of them moved their houses, bit by bit, to the upper site, while others built new log huts. These men were encamped on the great lode, but they had no idea that they had found anything but a gold placer similar in character to those on which they had been working in the canyons below. At the start of their work on Gold hill they made $5 per day to the man, and when they dug two or three feet into the decomposed rock they made more than twice as much.* Underneath their diggings were developed such famous mines as the Consolidated Imperial, Crown Point, and Yellow Jacket, but there was nothing at the surface to suggest the silver ore that was found soon afterward when they began to sink their little shafts into the lode.

The population of Johntown had dwindled to a small remnant by 1857, because by this time the lower-gulch and hillside diggings had become unprofitable. A few of the men went up the next canyon northward known as Six-Mile. Here also their prospecting was bringing them close to the line of the great lode, for they were working not near the banks of the Carson river but several miles up the canyon, searching for gold in the detritus on the hillsides rather than in the

* Dan De Quille, *Engineering and Mining Journal,* Vol. LII, p. 637; 1891.

gravel of a stream. Six-Mile canyon leaves the Carson river at a point about five miles north of the mouth of Gold canyon, and as the two canyons extend upward into the flank of Mount Davidson (which rises to 7941 feet above sea-level) they approach each other; Gold canyon terminates at Gold hill; Six-Mile terminates at the northern end of Virginia City; so that at their upper terminals the two gulches are only a mile

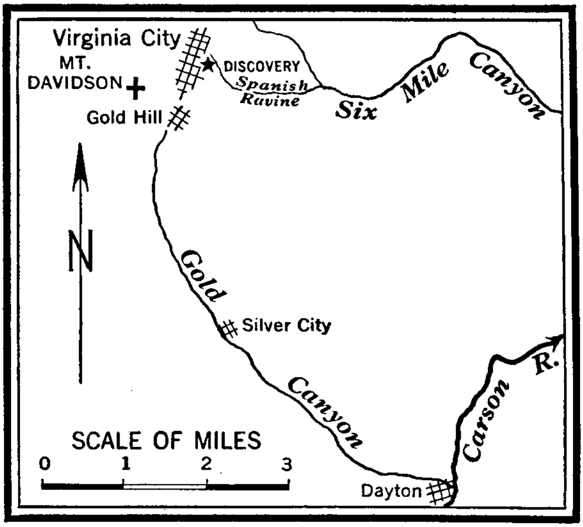


FIG. 7.—The approach to the Comstock.

and a quarter apart.* To these points on the great lode the diggers had come at last after 10 years of desultory digging.

Among the diggers that came to Gold Hill from Johntown were Patrick McLaughlin and Peter O'Riley. They found that all the promising ground had been staked, so they crossed the ridge to Six-Mile canyon. Here also the Irishmen found the ground fully occupied, therefore they moved to the mouth of Spanish ravine, above any signs of previous digging, and

* Virginia City is 1800 feet above Dayton, and Mount Davidson rises 1600 feet above Virginia City.

there on the hillslope they got some specks of gold in the loose dirt. Near-by was a small spring, by aid of which they began to wash the debris on the hillside, making $1·50 to $2·00 per day. They could not wash this earthy material in their sluice-boxes, because the supply of water was barely sufficient for the intermittent use of a rocker. They continued to work here until June, when, to increase their supply of water, they started to make a small basin in which the trickle of water might be held. When doing this they dug a little deeper than their previous trenching and at 4 feet they came into "a yellowish sand, mixed with bits of quartz, and friable black rock".* It has been stated, for example, by Lord, whom I have just quoted, that the yellowish sand was hornsilver, the silver chloride, a waxy mineral; but this is unlikely; it probably was only sand, that is, bits of quartz, of the yellowish tint characteristic of the Comstock outcrop. Most of the black rock was quartz that had become heavily stained with manganese oxide; but some of the black stuff was argentite, the sulphide of silver; and with it were mingled specks of gold, not readily visible. This material therefore looked unattractive; however, they had to test it, so they washed a hatful in their rocker, and were astonished to see the quantity of gold that was collected. At first the paleness of the gold and the unexpectedly large amount of it caused them to question the genuineness of their discovery. The gold was combined with so much silver that it was worth only $11 per ounce. They were accustomed to decomposed quartz, and they decided that they had broken into a patch of rich detritus. So they located two 50-foot placer claims.† They were overjoyed. Just then a lank fellow on a small horse came riding toward them. It was Henry Comstock, formerly a trader and trapper in the North, a talkative trickster.‡ He caught sight of the gold and guessed that something rich had been found. Dis-

* Eliot Lord, 'Comstock Mining and Miners', p. 38; 1883.

† Thompson and West, 'History of Nevada', p. 57; 1881.

‡ William Wright, 'History of the Big Bonanza', p. 397; 1877.

mounting, he fingered the gold and asked some questions. Then, impudently, he told the two Irishmen that they were trespassing on his property; he asserted that he had a ranch of 160 acres covering the ground, which included the waterhole and the trench in which the prospectors were at work. It was all bluff, a rank imposture, but he talked so loudly and so confidently that McLaughlin and O'Riley thought it best to pacify him by acceding to his demand, which was that he and his partner, Emanuel Penrod, should be given a share of the claim. When this had been arranged, Comstock asked for an additional 100 feet of ground in behalf of himself and Penrod, this being in return for the right to use the water of the spring. This 100 feet, he insisted, must be in the middle of the claim immediately south of the discovery claim. To all of which the Irishmen agreed. The date was June 8, 1859.

Meanwhile, a meeting had been called to frame regulations for a new mining district; therefore, to obtain an undisputed right to their claims, Comstock and his three partners concealed their discovery by filling the hole and obliterating other traces of their work. The meeting was held on the eleventh of June; the Washoe mining district was organized; the next day, Comstock and his partners, over whom he easily asserted loud-mouthed leadership, located 300 feet for each man and an additional 300 feet for the discoverers, making 1500 feet in all along the lode. Apparently Penrod had persuaded them that it was the top of a vein, not a placer; but the true character of the discovery was not yet recognized. At the end of June, a ranchman named B. A. Harrison was given a piece of the black ore, which he carried to Grass Valley, across the mountains, in California. There he showed it to James Walsh, who, in turn took it to Melville Atwood to be assayed, on June 27. It contained $3000 in silver and $876 in gold.* The result of the assay was not known until late at night, but at dawn of the next day Walsh and his friend Joseph Woodworth, both on horseback, with a pack-mule, had started for

* Almarin B. Paul, *Mining and Scientific Press,* Vol. XLV, p. 392; 1882.

"the eastern slope", as the Comstock district was known until the acceptance of the new name, Washoe, after the tribe of Indians that ranged along the eastern base of the Sierra. Within a few days, hundreds of eager men were on the way. The first Washoe rush had begun!

When Walsh and others that led the stampede from Grass Valley and Nevada City across the Sierra to the scene of discovery arrived there, they found Comstock and his partners still engaged in working their ore for gold alone.* However, the secret of the peculiar black mineral being a rich ore of silver soon leaked out, despite which Walsh succeeded in getting an option on Comstock's interest, one sixth, for $11,000, paying only $100 down. Comstock thought that the rich ore was merely a bunch or pocket, and was glad therefore to get a sum of money that seemed to him a fortune. McLaughlin sold his interest in September 1859 for $2500. O'Riley held on to his share of the mine, and eventually obtained, with dividends, the sum of $50,000. Walsh bought Penrod's share for $6200.† The prospect-hole of the two Irishmen became the Ophir mine, which yielded $17,655,000. If the Grosch brothers missed their chance, it is also a melancholy fact that the other actors in this mining melodrama profited but little from their endeavors; Comstock died miserably, by his own hand, in 1870; and both of those whom he deceived ended their lives as unhonored paupers.

The fortuitous character of these events is nothing new in the history of mining; blind Fortune has often stubbed her toe against rich ore since the miner invoked her aid in his search for wealth. Diodorus‡ tells us that "in the country of the Paeonians the farmers, cultivating the soil, often turned up bits of virgin gold with the plough". "Chance", says Pennant§ wisely, "was the general detector of metallic riches

* Dan De Quille, *Engineering and Mining Journal*, Vol. LIII, p. 112; 1892.

† *Mining and Scientific Press*, Vol. XXXIII, p. 112; 1876.

‡ Diodorus, XVI, 8.

§ Thomas Pennant, 'A Tour in Wales', Vol. I, p. 52; 1778.

in early times. The gold mines of Galicia [Gallaecia] were discovered by the plough; those of India by the casting up of hillocks by the pismires, or ants; the silver mines of Spain by the casual burning of wood. Trivial accidents, even to this age, have been the cause of mighty mineral discoveries. The great mine at Halkin was discovered by ditching; that at Llangynnog, in Montgomeryshire, by the slip of a woman ascending a hill, and baring the vein with her feet." This was written in 1810; the pismires are analogous to the gophers that dug up the earth in which Fennimore found the gold, and as for ditching, that has now become a recognized method of prospecting.

In August the first consignment of ore was taken to San Francisco by James Walsh and Henry Comstock; it was packed in sacks and small boxes that were carried on mules across the mountains. They sold 3151 pounds for $1·50 per pound. This induced the owners of the Ophir to ship their rich sulphide ore as fast as it was mined, so that at the end of the season, before the first snow closed the trail, they had delivered 38 tons to Joseph Mosheimer, of San Francisco, for reduction. The yield, after smelting, was $114,000, or an average of $3000 per ton; but the charge for reduction was $412 per ton and the transport of the ore cost $140 per ton. Mr. Mosheimer must have done nicely out of his metallurgical performance. The bars of white metal from Mosheimer's furnace were carried through the streets of San Francisco, to be seen by crowds of excited people, and by others, no less excited, that looked at them when they were displayed later in the window of the bankers, Alsop & Co., to whom the bullion was delivered. Despite the inclemency of the season, in the early spring of 1860, there ensued an eager rush to the Washoe diggings, up the Sacramento river in crowded little steamboats, over the mountains on foot or on horseback, through the snow, and across the plain to the Comstock, as the lode was already being called in compliment to its supposed discoverer. The distance from San Francisco to Sacramento is

90 miles, from Sacramento to Placerville, in the Sierra Nevada, 45 miles; from Placerville it is 117 miles to Virginia City.

The mining of silver was unknown in the western States prior to the discovery of the Comstock lode, and the pioneers of that period had but little knowledge of the metallurgic art required to extract silver from complex ores; but the fame of the bonanzas in the flank of Mount Davidson brought to the hectic operations all the science that was extant, to guide intensive exploitation on a scale hitherto undreamed. First the example of the Mexican miner was followed; on June 22, 1859, only two weeks after the discovery, the four locators made a contract with J. D. Winters and J. A. Osborn whereby these were to provide two *arrastres*, or Mexican grinding-mills, and the two horses required to run them, in exchange for two-sixths of the 1400 feet that had been located.* It may be added that Osborn soon sold his sixth interest for $7000 to George Hearst, an energetic mining-man who heard of the discovery from Atwood, and followed close behind Walsh when he came to the Washoe diggings. Hearst subsequently sold this part of the Ophir to Ben Holliday, of the Overland Stage line, for $30,000, and therewith bought his interest in the Ontario mine, in Utah, when he recommended it for purchase to his associates, James B. Haggin and Lloyd Tevis, in the year 1872.

In September, 1859, Woodworth and Hastings started two more arrastras on the Carson river near Dayton. These treated three tons each per day. They were followed by a Georgian stamp-mill of four heads, weighing 400 pounds apiece, erected by Logan and Holmes also on the Carson river in October of the same year. These stamps were moved by horse power. In the following year, 1860, Dr. Elias B. Harris brought a Howland nine-stamp portable rotary battery from San Francisco. This mill, with nine stamps in a circular mortar-box, of three pieces, was started on August 11, 1860, on ore that came from the Bowers mine. Only one ton per

* Thompson and West, 'History of Nevada', p. 57; 1881.

day could be treated; the mill crushed dry and the dust proved extremely troublesome, so a change was made to wet crushing. An improvement ensued immediately; the mill now treated ten tons per day, and $13 more was recovered from the ore. The charge for milling at first was $100 per ton, then $75, and in the spring of 1861 it was reduced to $50 per ton. "The cost of working the ore", says Harris, "was a little less than six dollars per ton . . . I hired my amalgamators for fifty dollars and sixty dollars per month. Engineers for one hundred dollars per month, working 12-hour shifts."* These low wages indicate the depression that prevailed in the district at that time. The retorted bullion was worth only $10 to $14 per ounce, and as the Bowers mine was deepened the value decreased further, in consequence of an increasing proportion of silver in the ore.

Meanwhile Almarin B. Paul was building a mill at the Devil's Gate in Gold canyon. The machinery was brought from San Francisco at an expense of $400 per ton, and the lumber cost $300 per thousand. This also was a rotary mill, which at first ran dry and then was changed to wet crushing. Paul and Harris competed for the honor of starting first, and they appear to have finished their mills on the same day, August 11. The first lot of ore that went to Paul's mill consisted of five tons of tailing from the arrastras on Gold hill; it yielded $84·56, or $16·91 per ton in gold and silver. The mills proved so remunerative that Paul built another of 48 stamps; this was erected at the foot of Gold Hill in 1861. Milling operations were handicapped by lack of water. In 1861 a tunnel in the northern part of Virginia City cut a good stream of water, and most of it was conveyed by ditch and flume to Gold Hill by Williams and Gashwiler, who sold it for one dollar per miner's inch, equivalent to about 2230 cubic feet per twenty-four hours. In 1862 there were 20 mills at work,† and in 1866 there were 66 mills, with 1226 stamps and

* Thompson and West, *op. cit.*, p. 68.

† J. Wells Kelly, 'First Directory of Nevada', 1862.

919 pans, these plants representing an aggregate expenditure of more than six million dollars.

The mention of pans is significant. For grinding, the Mexican used the *arrastre*, in which also he placed quicksilver to arrest the gold and silver. When the ore was refractory he introduced the *cazo*, or kettle, in which the ore was mixed with other chemicals, such as salt and bluestone (copper sulphate). Later the process was performed on a larger scale in a paved yard, or *patio*, from which it obtained its name, the mixing being done by the tread of mules. It was this process that was imitated in the American pan, a circular container resembling that of the arrastra, but made of cast-iron, 5 feet in diameter and 2 feet deep. This receptacle, invented separately by Israel Knox and Henry Brevoort, was provided with mullers, or weighted radial arms, for stirring and grinding the pulp. Steam was admitted to expedite chemical action. In Paul's mill, which was designed after careful experimentation, each of the pans held 300 pounds of ore and 40 pounds of mercury, to which were added a pint of salt and a few ounces of copper filings or copper sulphate. Hot water was admitted and copper crossheads in the pan served to arrest the amalgam, more of which was gathered from the bottom of the pan at intervals. This became known as the Washoe milling process.

Before the new process was fully developed, nearly fifty *arrastres* and several *patios* were in use on the high-grade ore of the Comstock, such ore having an assay-value of over $100 per ton and consisting mainly of heavy sulphides. The second-class ore that went to the stamp-pan mills contained some native silver and some native gold, together with silver sulphides (argentite, polybasite, stephanite) associated with blende and galena in a matrix of crumbly quartz. A great variety of pans, settlers, barrels, and tubs came into temporary use, but only two feeble attempts at concentration are recorded. The cost of treatment in custom mills was not less than $20 per ton until 1865, when prices were reduced

gradually to $16 per ton, with a deduction of $3 per ton when water-power was utilized. Haulage from Virginia City to the Carson river, a distance of seven miles, cost $4 per ton.

By 1866 the Washoe process had become standardized.* The ore passed first through Black jaw-breakers and then into batteries of five stamps, each of which weighed from 500 to 1000 pounds and dropped 8 or 9 inches at the rate of 90 times per minute. No amalgamation was attempted inside the mortars. The screens were either of brass wire-cloth, 40 to 60 mesh, or of sheet-iron perforated with holes $\frac{1}{40}$ to $\frac{1}{24}$ inch in diameter. From the batteries the pulp passed first into settling-pans; afterward it was shoveled into cast-iron pans, from 4 to 6 feet in diameter and 2 feet deep. Here the grinding and amalgamation took place. The pan had a false bottom of iron. The charge weighed from 1200 to 1500 pounds. Steam was admitted while the muller made 60 to 70 revolutions per minute. Quicksilver was sprayed by being pressed through canvas at the rate of 60 or 70 pounds to the charge. Two hours were devoted to grinding, and two or three more to amalgamation; then the contents of the pans were discharged into settlers, which resembled the pans, but were of larger diameter. Here gentle stirring expedited the settling of the amalgam and of any uncombined quicksilver. The amalgam was then collected, to be strained through a canvas bag, the residue being retorted. Sundry chemicals were added, such as salt, copper sulphate, and sulphuric acid. At one time many absurd nostrums were in use, including tobacco juice and sagebrush tea. The effect of the chemicals in the process was not well understood, as might also be said of its prototype, the *patio;*† it was questioned whether the chemicals served any useful purpose, because usually the quantities added were too small. The mercury and the iron, aided by heat and friction, were the principal agents in the reduction

* James D. Hague, 'U. S. Geological Survey, Exploration of the Fortieth Parallel', Vol. III, p. 193; 1870.

† T. A. Rickard, 'Journeys of Observation', pp. 140–145; 1907.

process. The loss of iron in the batteries and pans was as much as nine pounds per ton of ore.

The difficulty of treatment was in proportion to the richness of the ore, because the richer the ore the more of sulphide minerals it contained, therefore requiring more quicksilver and more grinding, and leaving a greater loss in the tailing. High-grade ore ($200 to $300 per ton) cost $50 per ton for reduction as late as 1867. The average charge levied by custom mills through the 'seventies was from $11 to $12 per ton. The recovery at first was from 60 to 65 per cent of the assay-value, but by re-treatment, in settling tanks or by concentration, the saving was increased sometimes to 85 per cent or more, the gain going, however, not to the customer but to the mill company. For many years the mills returned only 65 per cent, retaining anything more that they might be able to get out of the ore and from the tailing. This supplemental recovery had been the perquisite of the mill-owners from the beginning, and served to lessen the charge for treatment. The mills were owned by small groups of directors of the mining companies and they were enriched by means of this by-product, which arrangement was in entire accord with the code of ethics prevalent at Virginia City.

As soon as the critical metallurgic difficulties had been overcome, the production of ore was hastened, and a large population found employment at the mines. Virginia City, at an altitude of 6300 feet, became a hectic town of 12,000 inhabitants. Within a few years, however, the shallow ore-bodies showed signs of depletion; in 1870 the outlook was gloomy, but at the end of that year the Crown Point ore-shoot was cut at a depth of 1100 feet, and the Comstock took a new lease of life. Then came the discovery of the Big Bonanza in 1873.

The story of the Big Bonanza centers about four men: John W. Mackay, James G. Fair, James C. Flood, and William S. O'Brien. The leader of this group, and the most remarkable among them, was Mackay. Of Scottish-Irish origin, and a

ship carpenter by trade, he came to California in 1851. For eight years he worked in the Downieville district, with the usual scant success of the average placer miner of that period in California. In the fall of 1859, when the discovery of the Comstock became known, he packed his blankets over the Sierra and went to work in the mines at Virginia City. He acquired an interest in several properties and by 1863 had become the superintendent of three mines. Two years later the undeveloped Kentuck attracted his attention, whereupon he took the lead in disclosing a valuable orebody, the yield from which enabled him to acquire a comfortable fortune. Then, for several years, he was one of the unsuccessful operators of the Bullion mine. In the fall of 1868 he and Fair joined with two Irishmen, Flood and O'Brien, who had been running a saloon in San Francisco and had made money by speculating in stocks; these four formed a partnership for the purpose of obtaining control of the Hale & Norcross mine, which already had undergone extremes of fortune. Assessments to the amount of $350,000 had been levied at the end of 1865; after which, in 1866 and 1867, the mine had paid large dividends. In January, 1868, William Sharon entered the market, intending to take the control from Charles Low and his associates, whereupon a remarkable contest ensued. The Hale & Norcross property covered 400 feet along the lode, and was represented by only 800 shares. The selling price on January 8 was $300 per share, this quotation rising to $4100 on February 11, and $7100 a few days later. The market was in a panic and means had to be found to prevent the stock from being called on the exchange for over a month. Meanwhile a few shares were sold for as much as $10,000 each. At the annual election, on March 10, 1868, Sharon won a barren victory, for the mine produced only 16,536 tons of comparatively low-grade ore during that year. No dividends were paid; on the contrary, three assessments, aggregating $200,000, were collected. In May the capital stock was increased to 8000 shares, and toward the end of that year, 1868, the

quotation fell below $50 per share. At this juncture Flood began to purchase the stock, and before Sharon was aware the Big Four had secured the control. On March 9, 1869, they elected themselves trustees, or directors, of the company. The new directors promptly rescinded an assessment that had been levied, and by skilful management, aided by good fortune, they were able to pay dividends amounting to $728,000 during the following three years.

Of this group of four men that now had obtained a strong footing on the Comstock, Fair was an able mine superintendent, but unreliable; Flood was a clever stock-manipulator and a keen business-man; O'Brien was a light-weight; Mackay, on the other hand, was a big man, one of the best men that our Western mining industry ever produced. Reticent, modest, self-effacing, he was also forceful, courageous, and persistent; he was shrewd but generous, a captain of industry endowed with constructive imagination, as is proved by his laying a transatlantic cable in face of the sustained opposition of the Anglo-American telegraph companies; and subsequently his Postal Telegraph system likewise was established despite all sorts of difficulties placed across his path by the existing monopoly, the Western Union Telegraph Company. Shortly before he died he undertook to lay a cable across the Pacific Ocean to Honolulu, Guam, and the Philippines; he did this without any subsidy or guarantee, but with a largeness of mind that proved his public spirit.

One of the first steps taken by this group was to break the mill monopoly of the Union Mill & Mining Company, controlled by William Sharon and the Bank of California; the Big Four took hold of the Bacon mill at Silver City, and shortly afterward they bought two more mills near-by, all of which they enlarged and improved. Fair became superintendent of the Savage mine, but failed to find any rich ore. The Hale & Norcross orebody was nearly exhausted; it became necessary to find a fresh outlet for the speculative energies of the partnership. So they bought the Consolidated Virginia

mine as a gamble; it was a unification of three small mining claims covering 1010 feet along the lode. Prospecting operations in this ground had been disappointing, and the shares stood at 1⅝ in 1871 when two-thirds of the stock was bought by Mackay and his associates for about $50,000. The shaft was 525 feet deep at this time, and it was down to 710 feet in 1873; meanwhile a drift on the 1200-foot level of the Gould & Curry had been extended through the Best & Belcher ground into the Consolidated Virginia mine. This drift was turned westward toward the foot-wall of the lode. In September 1872, at a point 178 feet north of the Best & Belcher line, the drift broke into a fissure seven feet wide filled with clay mixed with crushed quartz and broken rock, all of which averaged about $20 per ton. After following this fissure northeastward for 200 feet a small body of $40 ore was encountered. The shaft was sunk to the level of the drift, and a new drift extended from the shaft southeastward cut into ore at a distance of 250 feet from the shaft on March 18, 1873. A chamber 50 feet wide, 25 feet high, and 140 feet long was excavated, all in ore assaying from $50 to $600 per ton. The subsequent average mill-return was $40 per ton. During this period of successful development Captain Samuel T. Curtis was superintendent, although Fair succeeded in stealing the credit for the discovery of the big orebody.

The discovery that made the Comstock world-famous was made accidentally, as many discoveries of ore have been made both before and since. Prior to this event all of the orebodies had been found along the foot-wall, whereas the Big Bonanza lay in a vertical rift in the hanging-wall, which was 500 feet east of the foot-wall. The discovery would not have been made in the ordinary course of exploration if the drift from the adjoining mine into the Consolidated Virginia had not followed a fissure in the hanging-wall rock that led northeastward directly away from the parts of the lode previously penetrated. Eventually this part of the lode would have been

explored, certainly, but the discovery in 1873 was fortuitous to the extent indicated.

The bonanza was cut in the Consolidated Virginia ground on the 1200-foot level, as we have seen; and it was tapped at successive levels down to 1500 feet. Later the orebody was proved to persist to a depth of 1650 feet, where it ended abruptly as on a floor. Crosscuts showed the width of the ore to be as much as 200 feet, and connecting winzes demonstrated continuity. The bonanza was found to extend into the territory north of the Consolidated Virginia shaft that had been acquired in December 1873, whereupon the 1310 feet of ground between the Best & Belcher and the Ophir mines was divided, the southerly 710 feet being held by the Consolidated Virginia and the northerly 600 feet by the California. Up to 1870 the ground that became the Consolidated Virginia and the California mines had been explored down to 500 feet in a haphazard way and without the finding of any rich ore. In 1876 the Consolidated Virginia yielded 142,679 tons of ore, from which $16,657,649 was obtained; and in the same year the California yielded 128,801 tons, from which $13,400,841 was obtained. A force of 1000 miners was employed in the two mines in 1877 in the effort to rush production, with an eye on the stock exchange. In 1877 the output of the two mines was

Virginia.............	144,400 tons, yielding $13,734,019
California...........	217,432 tons, yielding $18,924,850

Altogether the two mines yielded $150,000,000 in metals and paid $78,148,800 in dividends, during a period of 22 years. Most of it, however, was produced in five years, 1874 to 1879, from a million tons of ore that averaged $100 per ton. For three years, after the big orebodies were uncovered between the 1100-foot and 1600-foot levels, the Consolidated Virginia and California mines produced $3,000,000 per month, and dividends at the rate of $1,080,000 per month were paid by each of the two mining companies, which, by the way, were

not united again until 1884, to become the Consolidated California & Virginia Mining Company. The coupling of the names of the Consolidated Virginia, itself a consolidation, and of the California, another consolidation, in references to these events has caused a confused idea that they had been already joined under one ownership; but this did not take place until both mines were impoverished. In 1876 Mackay, in charge of both mines, took out $6,000,000 in one month for the purpose of making an exhibit of bullion in the Centennial Exhibition at Philadelphia; but the exhibit was not made.

This enormous production incited an orgy of stock gambling in all the shares of the mines along the Comstock lode, whether good or bad; as much money was made in speculating in the stock of the poor ones as in that of the rich ones. Mines sold for millions that never had a pound of ore. Claims were staked forty miles out in the desert. In 1870 Consolidated Virginia stock was offered at $1 per share; in June, 1872, it could be purchased for $15, and in November of the same year it rose to $176; then, in January, 1875, to $700; at which price the valuation of the mine was $75,600,000. The California shares rose from $37 in September, 1874, to $780 in January, 1875, giving the mine a valuation of $84,240,000. In 1871 the two mines were valued at less than $50,000; in 1875 they stood at $160,000,000.

During the early years, trading in mining property was done in units of a foot, the number of feet along the lode being the measure of a company's possessions; later the stock was issued in multiples of the feet of ground owned by a company; thus the Ophir, owning 1400 feet, had 5600 shares; and the Gould & Curry, with 1200 feet, had 4800 shares. These Gould & Curry shares sold for $1600 on July 10, 1864, and for $700 on June 29, 1866; indeed, the ups and downs of the San Francisco market in Comstock shares make even the recent hysteria on Wall Street seem somewhat tame. The shares of the Crown Point jumped from $2 to $1825 apiece in less than two years; within eight months, in 1878, the shares of the Sierra

Nevada mine soared from $4 to $275, such inflations being due chiefly to market manipulation and insane optimism. Money was made easily and lost recklessly; the Comstock became a byword for tricky dealing, extravagant management, and fickle fortune.* Rossiter Raymond, when Commissioner of Mining Statistics for the Federal Government, recorded his impressions of the manner in which mining on the Comstock was conducted in 1868:

"All the explorations in the barren mines of the Comstock could have been executed with the money flung away by the mines that have had, for a time, rich ore . . . As the prospects of mining on the old wasteful plan grow darker and darker, officers, agents, and stockholders bend their energies to save what they can by speculation out of the approaching wreck. We might well afford to leave them to their fate, but for the fact that the effect of an abandonment of the Comstock lode would be almost fatal to systematic and permanent mining in the Pacific States. It would confirm the mischievous feeling that mining is half grab and half gamble; that the only way to make money at it is to dig out what rich ore you can get, and then find a fool to buy the property; or failing that, to make a fool of that collective individual, the public, and to 'unload' yourself of your stock."†

The best mines were much over-valued, and many of those quoted at high figures were actually worthless. False reports were forwarded from Virginia City. Visitors were permitted to go underground so that their ignorant ecstacies might fool the public. Obviously there were extraordinary opportunities to win wealth, or poverty. During the 'Con. Virginia' boom of November and December, 1874, and January, 1875, the buying of shares on a margin was done on such an enormous scale and so recklessly as to invite disaster. It was impossible

* T. A. Rickard, 'The Comstock of To-day', *Cassier's Magazine*, September, 1901.

† Rossiter W. Raymond, 'Mineral Resources of the States and Territories', p. 51; 1869.

to find enough money on the Pacific coast to finance these wild dealings; even on a liberal estimate not more than \$20,000,000 was available for such purposes at that time, yet \$50,000,000 of stock changed hands in one month (December, 1874), and the market value of the listed stocks amounted to \$262,000,000 on January 7, 1875. Five months previously the total valuation was \$38,000,000; within six years it fell to \$7,000,000. In 1875 it was evident to sagacious onlookers that a fine opportunity was offered for a bear raid, and James R. Keene, at that time the shrewdest dealer on the San Francisco exchange, with other professional brokers, availed himself of the chance to make a fortune while the quotations crumbled in financial ruin.

The "imperial treasure-chamber", shared by the Consolidated Virginia and the California companies, was described in extravagant terms. Confident predictions were made of a yield of \$34,000,000 annually for at least 10 years. Even the Director of the Mint endorsed such wild expectations, and in his 'Annual Report' for 1875 he quoted from the report of a Professor Rogers, who said: "It would seem fair to conclude that with proper allowance, the orebody equals an amount, which, taken at the actual assays, would give as the ultimate yield of the two mines, \$300,000,000; but to guard against a chance of over-estimating, I take the assays at one-half that ascertained, which will place the production at not less than \$150,000,000".* The assays were those of grab samples; he had not sampled the ground systematically; he was not a mining engineer, and consequently he had less reason for halving his estimate than for rejecting it entirely. The actual production of the two mines from the blocks of ore estimated by the professor did not exceed \$90,000,000. The total output of the Comstock mines was \$350,000,000, of which 55 per cent was in silver and 45 per cent in gold.† The total profits distributed to the shareholders amounted to \$116,000,000, of

* *Annual Report* of the Director of the Mint for 1875, p. 83.

† John A. Church, 'The Comstock Lode', p. 5; 1879.

which $74,250,000 was contributed by the two mines that shared the Big Bonanza. From 1885 to 1895, when the underground fire had been checked and milling charges had been reduced to $6·50 per ton, the Bonanza yielded an additional 895,000 tons of an average value of $20 per ton from old fills and from the margins of the old stopes, enabling an additional $3,898,800 to be paid in dividends.

The professional mining engineer is justified in believing that the Comstock did more harm than good to legitimate mining; it encouraged the idea of the sudden acquisition of wealth without work, of finding ore without systematic search, of forming share-mongering companies on mere expectations, with a view to market jugglery. The orgy of gambling, trickery, and extravagance dishonored a basic industry and drew into the ranks of honest workers, skilled engineers, and sagacious managers, a motley crew of cheats, rogues, and swindlers. The Comstock undoubtedly had a bad, and lasting, influence on the morale of mining, but the enormous output of the precious metals had a beneficial effect; in the first place, it brought a most timely contribution of specie to the treasury of the Federal Government during the critical period of the Civil War, and later in facilitating the tremendous industrial expansion that ensued when the Southern Confederacy had laid down its arms, and the energies of the people of the United States were directed to the development of their expansive western domain.

The wealth that came from the mines of the Comstock had another effect. The actual richness of the mines was exaggerated in fabulous stories that not only caused the price of silver to diminish but frightened several European countries into the demonetization of that metal. The fact that the value of the bullion from the Comstock was nearly half in gold was overlooked. In 1871 Germany adopted the gold standard and ceased the minting of silver; in 1873 the United States, by Act of Congress, discontinued the coinage of silver dollars; in the same year Germany provided for the retirement

of its silver coins and the sale of the bullion; in 1874 the governments of the Scandinavian countries demonetized silver; in 1875 Holland suspended the minting of silver for private account and established a gold coinage; in 1876 France and Spain did likewise. How hysterical these hurried demonetizations proved to be is indicated by the fact that the price of silver on the London market declined only from 60 pence in 1861 to 52 pence in 1881, and today there is ample cause for regret that our bimetallic standard was abandoned in favor of a monometallic gold standard at the time when a temporary increase of silver production seemed threatening to the world's financial stability.

The unwatering of the Comstock was a noteworthy event. The mines on the flank of Mount Davidson were subject to flooding even before they attained any real depth. Several shallow adits were made to drain them while they were yet in the early stages of development. In October, 1869, the Sutro tunnel was commenced. This famous adit starts from the valley of the Carson river, and has a length of 20,145 feet, or about four miles; it intersects the lode at the Savage shaft, at a point 1895 feet below the outcrop. Eight years, and four and a half million dollars, were consumed in the enterprise.* The idea was to drain the mines, but long before the tunnel reached the lode the workings had been extended fully a thousand feet below the level of the tunnel, and most of the ore had already been removed. The amount of water that flowed out of the tunnel at one time exceeded 7000 gallons per minute. Nevertheless, as stated, this enterprise, like many other tunnel schemes, was finished too late, and failed therefore to fulfil the purpose for which it was primarily intended. The orebodies found below the level of the Sutro tunnel were insignificant in size and richness as compared with the bonanzas of the upper levels, and therefore, although the stimulus of the stock market caused the deeper developments to be continued for a time, the last deep mining ceased in 1886, and

* The actual cost of driving the tunnel was $2,096,566.

the lower workings were allowed to fill with water. Since then sundry efforts have been made at intervals to galvanize the Comstock mines into productive life, but they have proved short-lived and abortive.

The miners of the Comstock deserve a word of praise; they met and overcame more obstacles and more difficult obstacles than any that the brothers of the pick and gad had ever faced before; and the hard-bought experience that they gained they carried with them all over the world, and most notably to the big mines of Montana, Colorado, and Dakota, as the history of those regions abundantly testifies.

The visitor to Virginia City, as I saw it 20 years ago, arrived rich in remembrance of its past, and left poor in the realization of its present. One was taken into enormous shaft-houses dilapidated by the heavy hand of time, and one was shown huge engines of antiquated design, only to feel the ponderous silence of abandonment. It was interesting, however, to note how modern winding engines had been evolved from the clumsy and complicated patterns of a former day. The Comstock was a great school of mechanical design. In the mines along the big lode the American engineer first faced the problem of deep development, but it may well be doubted whether it was a good school of mines in any department save the mechanical. There was skill in the erection of machinery, and there was ingenuity in the adaptation of European methods of timbering to unusual conditions; but in the application of geology to mining and in the improvement of underground practice, there was not any such advance as was made at the mines of Colorado, Michigan, and Montana. Possibly the geologic conditions were unfavorable to such research. On the whole, looking back at the record of the Comstock, we may conclude fairly that notwithstanding the mechanical skill of the constructing engineers at Virginia City, the Lode did more harm than good to mining, because it accentuated the gambling phase and subordinated the industrial function in its feverish operations.

The judicial tribunals of the new Territory of Nevada were subjected to gross corruption. At the time when the Territory was organized, the Civil War was engaging the attention of the Federal Government, so it is not surprising that the doings of the small community at Virginia City were of slight consequence. The judges were paid only $1800 per annum, and their pay came to them in paper currency that was worth at times hardly more than half of its face value. Moreover, the cost of living in the mining region was abnormally high. Despite these conditions, the judges maintained a style of living that considerably exceeded the amounts of their salaries; yet from day to day they were called to pass upon titles involving property worth millions of dollars to litigants not at all scrupulous in their methods. The bribery of judges and juries became so flagrant as to be censured even by the not too fastidious newspapers. Mass meetings were held to denounce the corruption of the Territorial courts. On January 16, 1864, William H. Stewart exposed the scandalous dealings in connection with the Chollar-Potosi case and thereby initiated a petition for the removal of all three judges.* On Stewart's further forceful action shortly afterward the three judges telegraphed their resignations to President Lincoln. Then an attempt was made to have a San Franciscan lawyer, named Swift, appointed Chief Justice of Nevada, but, again under the leadership of Stewart, the recognized leader of the Nevadan bar and later Senator, a public protest ensued against any appointment until Nevada became a State and could elect her own judges. Thereupon the President withdrew the nomination of Swift, and the Territory was left without a judiciary until October 31, 1864, when Lincoln proclaimed Nevada a State.

On the Carson river, it was difficult, even 20 years ago, to find the sites of the mills that had served the Comstock in its hectic days. This river has seen many changes. Placer washing for gold made it important before the Comstock was

* Sam. P. Davis, 'The History of Nevada', Vol. I, p. 288; 1913.

discovered; later, the mills were grouped along its waterway, and then the Sutro tunnel gave it a short-lived animation. When that ceased the industrious Oriental folk grew vegetables for the surviving population. When I was there in 1901 the unlovely quiet of abandonment rested on the whole district. The Chinaman alone was superior to his surroundings. Amid the general decay he continued to give life to the green spots that his patient hands had won from the sterile surface. The coolie and his kitchen-garden formed a picture that was the very antithesis of the volcanic energies that once rioted at the mines of the Comstock. "Cold upon the dead volcano falls the gleam of dying day." The mines are idle, the sunlight falls on abandoned shaft-houses, the rain rusts the motionless machinery, but

"The river still is winding, still is winding
Past the gardens where the Mongol tends the cabbage and the leek."

CHAPTER VI

EARLY DAYS IN COLORADO

The beginning of Colorado's mining industry is linked on one side with that of the Appalachian districts and on the other side with that of California, because the first discoveries were made by pioneers when on their way from Georgia to California. In the summer of 1849 a party of seven Georgians were taking a herd of thoroughbred horses across the continent to the Pacific coast. They reached Camp Lyon, on the Arkansas river, in October, and, meeting James Dempsey, a Government guide, they were persuaded by him that it was too late to cross the mountains that season. His advice was accepted, and, moving northward, they established a winter camp at the junction of Cherry creek with the Platte, close to the site of the city of Denver. Upon a sand-bar, lining the south side of the river, they built two cabins. During the closing months of 1849 they prospected the alluvial banks of Cherry creek, but they made no attempt to penetrate into the mountain canyons, near them, westward, for fear of the Indians.* They found gold in several places along Cherry creek, and particularly at a spot 16 miles up the stream from their camp. From the feathers of the wild geese that they shot they obtained quills in which they placed their gold-dust.

This party of Georgians consisted of Dr. L. J. Russell and his brother, Green Russell, also A. T. Lloyd, G. W. Kiker, and P. H. Clark. Early in 1850 they crossed the main range of the Rocky Mountains by the Bridger pass and went on to California. They mined near Downieville, and were successful. Occasionally mention was made by them of the gold

* T. A. Rickard, 'The Development of Colorado's Mining Industry', *Trans.* Amer. Inst. Min. and Met. Eng., Vol. XXVI, p. 334; 1897.

they had found in western Kansas (for Colorado was then part of Kansas) on their way across the plains. The goose-quills gave evidence in proof of their story. In the spring of 1857 they, with others, sold out their interests in California and returned to Georgia. Before separating, it was agreed among them that in the near future they would organize a prospecting party for the purpose of going to western Kansas in search of gold. In May, 1858, therefore, eleven of them met at the Planters' House at St. Louis. In addition to the original party of seven, there were present J. A. O'Farrell, three men of the name of Chastine, and another named Fields. All save two had been to the Californian diggings. Having organized the expedition, they went to Leavenworth by water and thence to Camp Harney along the military road. Late in July they left this frontier post, accompanied by an escort of twenty soldiers under the command of Captain Lyon.

In August the party reached their former camp on the Platte. They found plenty of the wild cherries that gave the tributary stream its name. As soon as camp had been pitched, they went to the places where Russell and his friends had discovered gold in 1849. They found enough more to encourage them. Prospecting parties were organized. Some of them went northward until they came to a mountain stream full of large boulders. They went up to the forks of this Boulder creek. In a small basin on the left branch they found gold, and called the locality Gold Run. Another party went across the intervening ridges to Fall river, and from there to Spring gulch. They did not descend into the northern valley of Clear creek at that time, but they crossed Quartz hill and found rich gravel in Russell gulch, which was named after the discoverer, Green Russell. It was now too near winter to start systematic mining operations, so they returned to the base camp. Six of the party went east to procure provisions, returning in the spring of the following year, 1859.

That was the year of golden discovery. At the close of the preceding season a rumor of rich diggings had crossed the

plains and had started a rush westward. On July 24, 1858, the 'Weekly Kansas Herald' had announced that "on the headwaters of the South Fork of Platte, near Long's Peak, gold mines have been discovered, and 500 persons are now working there".* The facts are absurdly confused, but the announcement served to excite public interest. Companies were organized all over the Missouri valley for the purpose of

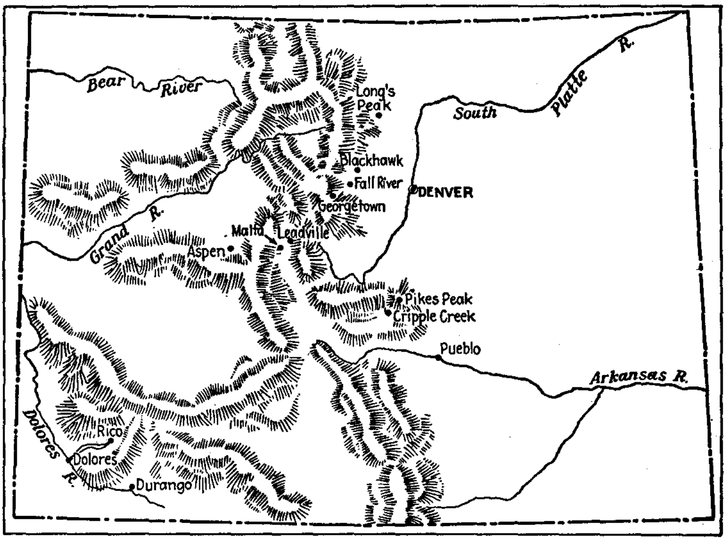


FIG. 8.—Map of Colorado. (*Reproduction licensed—base material copyrighted by Rand McNally & Company.*)

an expedition, and the newspapers offered sage advice concerning the outfit suitable for prospective, and prospecting, miners. Many began to arrive early in 1859. In April, George Jackson, an experienced Californian miner, while hunting amid the mountains on the south branch of Clear creek, saw a stream along which the sand looked promising. Taking his sheath-knife he dug enough sediment to fill a 'tin'

* James F. Willard, in 'Colorado: Short Studies of its Past and Present', p. 103; 1927.

cup and washed it in the stream, recovering a dollar's worth of gold. Whereupon he and others started to work systematically. Most of the men came from Chicago, so the creek took their name, although later Idaho Springs became the principal settlement. In May, John Hamilton Gregory, with J. M. Cotton and his brother, William Cotton, went up the northern branch of Clear creek. At the head of the gulch Gregory discovered the lode that was named after him. The date, May 6, 1859, is the birthday of Colorado's mining industry.

Gregory's first panning of the soft material of the outcrop yielded four pennyweights of gold. He employed five men and took out $972 in one week by aid of a sluice-box. With his friends he framed the first mining regulations in Colorado, allowing 200 feet on the vein to the discoverer and 100 feet to any later locator. These regulations, however, were soon modified, a mountain (or lode) claim being reduced to 100 feet long by 50 feet wide, while a gulch (or placer) claim was given 100 feet up and down the creek, from bank to bank. The first arrastra, moved by oxen, was set to work in July 1859; and a week later an arrastra driven by water-power was started by J. D. Peregrine at the Gregory diggings. In October, of the same year, J. Prosser brought a stamp-mill of three heads and set it up at the Gregory mine; this mill crushed the headings of the sluices, that is, the coarse gold-bearing stuff that remained at the head of the sluice-boxes. Most of the mining at this time in the district, later known as Gilpin county, was confined to the surficial ore of the weathered outcrops, which was treated as alluvium. Tramways were built down the hillsides to the gulches, where water was available for sluicing. Gregory was most successful in his prospecting and made a small fortune, but, being an inveterate gambler, he died poor in 1864.*

Among the adventurers attracted to this part of Colorado was George M. Pullman, later famous as the inventor of the sleeping-car, the idea of which he is said to have got from the

* Frank Fossett, 'Colorado', p. 212; 1878.

double-decked miners' bunks. He worked on the Gregory lode, having secured claims No. 7 and No. 8, together with half of No. 6, all of which he sold in 1864 at the price of $1000 per linear foot. Each claim was 100 feet long. This transaction started him on his successful career. Later he had a hardware store in Central City.

Soon after Gregory's discovery other veins were located: the Bates, on May 15; the Gunnell and Kansas on May 25. The Bobtail was discovered in June. By the first of July, 1860, there were sixty little mills in operation. Everything betokened prosperity, but soon the discovery shafts penetrated through the gossan into pyritic ore, from which the gold was more difficult to extract. However, the richness of the upper portions of the lodes was such as to leave a handsome margin for dividends, in consequence of which, during the winter of 1863 and the spring of 1864, several mines were sold in New York and Boston. A stock boom ensued, only to collapse ignominiously in April. Here we may note the appearance of a myth that early gained credence among the miners and served to deceive the public for many a long day. In a report made by J. P. Whitney, in 1867, as commissioner from Colorado to the Paris exposition, it is written: "A peculiarity of the Colorado gold veins is, that they are invariably found richer the deeper they are sunk upon".* Indeed, it would have been a unique peculiarity, and would have compelled the mining engineers, if they were worth their salt, to sink to at least two or three thousand feet before beginning to stope. That delusive idea of enrichment in depth has been riddled by the bullets of fact;† it was like the kingdom of heaven in that it came not by observation. At this time also there appeared a number of incoherent processes, with the promise of a 100 per cent extraction. The inexperienced chemist, in the hands of the unscrupulous promoter, followed

* 'Colorado', Schedule of Ores, Paris Exposition; 1867.

† T. A. Rickard, 'Persistence of Ore in Depth', *Trans.* Inst. Min. and Met., London, Vol. XXIV, pp. 3–190; 1915.

the stockjobber in ruining a promising industry. Gilpin suffered eclipse. Many mines were compelled to close down; others were operated with a ruinous loss of the gold in their ores, which defied known methods of treatment. Meanwhile the leasing of claims to working miners and the consolidation of adjacent mines served to diminish expenses. Then the smelter-metallurgist came to the aid of the baffled mill-man. In 1867 the Boston & Colorado Smelting Company was organized by N. P. Hill, formerly professor of chemistry in Brown University. In June the first experimental plant was erected at Blackhawk. In January, 1868, the smelter opened for business. In 1873 the shipment of matte to Swansea, in far-away Wales, was stopped, and a scientific effort to extract the gold and silver from the matte was made successfully by Richard Pearce, who was the pioneer of copper-smelting practice in the Rocky Mountain region.*

While these problems of reducing complex ores were being solved under genuine scientific guidance, the mining industry of Colorado was winning fresh territory southward, amid the snow-clad mountains whose waters feed the San Juan river. In 1861 a party of prospectors, guided by Jim Baker, crossed the Sangre de Cristo range and reached the headwaters of the Animas river, which the Spaniards named *el rio de las ánimas perdidas*, the river of lost souls, in recognition of the gloomy magnificence of its scenery. At the time when the American pioneer penetrated into these mountain fastnesses the region was in possession of the Ute Indians, and prospecting was rendered difficult. The Baker party, overtaken by heavy winter snows and attacked by the Indians, suffered severely, only a few escaping over the mountains. Before they were driven out of the region they had tested the river gravels in several places, and the remains of their placer workings survive in many a secluded gulch to tell of these beginnings of mining.

* T. A. Rickard, 'Richard Pearce, a biographic sketch', *Engineering and Mining Journal*, March 10, 1928.

In 1864 a guide named Robert Darling brought a party of Army officers and Mexicans from Santa Fe to examine the outcrops of sundry lodes that he had found on the Dolores river. This party built an adobe furnace and spent an entire summer in an ineffectual attempt to smelt the lead-zinc ores occurring near the present site of Rico. At the end of the season they returned to Santa Fe, and the Dolores valley reverted to the trappers and hunters, who found beaver along the stream and bear on the hillside. In 1870 a party of prospectors sent by Governor Pile of New Mexico did some placer mining in Arrastra gulch and while thus engaged Miles T. Johnson discovered the outcrop of the Little Giant vein, the ore from which was treated in a Mexican *arrastre*. It is said that, in 1871, 27 tons of ore yielded $150 per ton in gold. From this mine came the first ore to be shipped outside.* Two years later troops had to be sent into this region to expel the miners, who were there in violation of a treaty signed in 1868 whereby the Utes were secured in sole possession. In 1873, however, the Utes agreed to cede the San Juan mountains to the United States government under the terms of the Brunot treaty.

Meanwhile, despite redskins and snowslides, the two chief perils that the prospector had to face, the search for minerals had persisted. In 1872 the Little Giant company was organized at Chicago, and in the following year a five-stamp mill, with a Dodge crusher, replaced the arrastras. In 1874 there was a rush of miners, chiefly from northern Colorado, to the San Juan region. Forthwith mining operations were started in many localities, notably on the Aspen, Prospector, and Susquehanna claims, all on Hazelton mountain, whence several hundred tons of ore containing copper and lead were brought for treatment at a smelter erected north of Silverton by Judge Green, of Cedar Rapids, Iowa. The machinery came on burro-back from Colorado Springs, which was then the

* F. L. Ransome, 'The Silverton Quadrangle, Colorado', U. S. Geological Survey, p. 19; 1901.

terminus of the Denver & Rio Grande railroad. This plant, which started work in 1875, had a capacity of 12 tons per day. The bullion was shipped on mules to Pueblo. In 1875 J. A. Porter, a Freiberg graduate, metallurgist to Green & Company, introduced the siphon-tap, and in the following year he erected the first water-jacketed furnace to be used in Colorado.

The development of more mines soon rendered the Green smelter inadequate; and in 1880 the works of the San Juan Smelting & Refining Company were erected at Durango, which locality is in the centre of excellent coalfields. This was one of the instances of the logical tendency to centralize the smelting industries of the region in the valleys, where the junction of the railroads from the adjacent mountains enabled the metallurgist to obtain the necessary mixture of ores. Thus, in the course of time, the large reduction works of Colorado became concentrated at Denver and Pueblo, with Durango and Leadville as subordinate centres.

Raymond, in his report for 1869, outlines the character of the business done between the local smelter-men and the miners.* He says that Professor N. P. Hill, in charge of a smelter at Blackhawk, in Gilpin county, paid his clients 20 per cent of the value of the gold in a 2-ounce ore, 30 per cent of the value of the gold in a 3-ounce ore, and, progressively, as much as 50 per cent of the gold-value of a 6-ounce ore. This last means that for an ore containing $120 in gold, he paid $60; that is, he charged $60 for smelting, plus loss of gold in smelting. For the silver in the ore, he paid 75 cents, when silver was worth $1·29; and he deducted as many ounces of silver as there were percentages of copper; that is, he deducted 6 ounces of silver if the ore contained 6 per cent of copper. But he paid $2 for each percentage of copper, deducting 0·5 per cent from the amount indicated by wet assay. So he paid $2 for each 20 pounds of copper, at a time when copper was selling for 23 cents per pound. No account was taken of less than one ounce of silver, one percentage of copper, or one-

* Rossiter W. Raymond, 'Mines and Mining', p. 363; 1870.

quarter ounce of gold. Raymond remarks: "It is understood that Professor Hill will before long enlarge his works". It would seem that he might have done so most profitably, but, as Raymond himself suggests,* on his own exact knowledge of the conditions governing such an enterprise, the supposed immense gains made by such reduction works were largely imaginary. A contemporaneous smelter across the hills at Georgetown was unable to conduct its business profitably even when receiving $100 per ton for the treatment of custom ores. Receipts of ore were intermittent and shut-downs for repairs were frequent. The shipment of bullion was costly and the time in transit was so long as to entail a burden on the company's treasury. Returns from the metals extracted from ore purchased for cash were often delayed six months. Materials of construction were usually not only costly, but were often not obtainable. A piece of round iron, to make bolts, for example, could not be found by a smelter manager although he searched in all the neighboring mining centres. Moreover, the uncertain life of individual mines, most of them mere prospects, and the vagrant character of the miners, who were attracted by every rumor of a new discovery to drop work at one place for the sake of a better chance elsewhere, introduced factors of uncertainty that undermined the stability of any smelting enterprise that was dependent, as all of them were before railroads had been built, on a local supply of ore. The only cure for these harassing conditions was the development of mines so large and so productive as to ensure a steady tonnage of ore of uniform character.

It is pleasant to quote Raymond because he was a famous personality in American mining affairs for half a century. As statistician, reporter, and commissioner under the Federal government at the beginning of the great era of mining development that followed the discoveries of gold in California and silver in Nevada, he exerted a wide influence by reason of his intellectual vigor and high character. As editor of the

* Rossiter W. Raymond, 'Statistics of Mines and Mining', p. 350; 1871.

'Engineering and Mining Journal', which became influential when directed by him, from 1867 to 1890, he won the leadership of the mining profession, and as secretary of the American Institute of Mining Engineers, from 1884 to 1911, he exercised a remarkable influence, especially on the younger men, who were greatly attracted by his brilliant speeches, by his forceful writings, and by the charm of his personality. He was a convincing publicist. Under his editorship the transactions of the Institute became a splendid reference library for those taking part in mining affairs and an exemplar of good literary style in technical publications. He exercised an immense influence for good in his day and generation; "for fifty years the force of his personality was felt among the men that were organizing and directing the mining industry of a continent; for fifty years he did not fail to write a Christmas story for the children of his Sunday-school; he was a friend to the old and to the young. Age could not wither him nor custom stale his infinite variety. He influenced those that today are influencing others; his spirit still moves among men. Blessed be his memory".*

Greater discoveries of mineral wealth were yet to be made in Colorado. The mining excitement of 1859 had been started with a tale of gold having been found on Pike's Peak, a noble mountain that overlooks the plains of central Colorado. Many of the wagons that crossed the prairies bore the joyous device 'Pike's Peak or Bust', and some of them returned later in the summer over the same route with their motto changed significantly to 'Busted'. It is true, as we have seen, gold was found in the Clear Creek and Gilpin districts at that time, but none was discovered at the foot of Pike's Peak, and to those who went thither the expedition was a fiasco. Early in the following year, however, several scattering bands of diggers ascended the Arkansas river. One party went westward as far as the headwaters and into California gulch, where

* T. A. Rickard, 'Rossiter Worthington Raymond, A Memorial', p. 13; 1920.

they encamped. At noon, of April 6, 1860, John O'Farrell, when breaking through the snow to obtain water for his coffee, tapped the creek, and in the sand he found gold. The pieces of porphyry that he saw amid the gravel reminded him of similar conditions he had observed on the Feather river in California, but little did he guess the significance of those rock fragments or the enormous wealth that the porphyry covered on the neighboring hills. George Stevens and his party arrived soon afterward. The discovery claims were just above the site of the A. Y. and Minnie mine, in the district that became known as Leadville.

Here we may recall the fact that Meyer Guggenheim, the founder of the Guggenheim firm of mining and metallurgical financiers, became interested in mining at first by means of an involuntary participation in the ownership of the A. Y. and Minnie mine, at Leadville, in 1884. He had loaned $5000 to A. J. Graham, a publisher of Philadelphia, who in turn had lent money to Harsh and Carey, the owners of the mine. When this mining enterprise failed, it passed into the hands of Graham and Guggenheim, each owning one half. At that time Meyer Guggenheim was a lace merchant; he had come as a poor Swiss immigrant to Philadelphia in 1864, and had started as a petty trader. He was shrewd and acquisitive of every kind of information; so he had prospered. The mining venture at Leadville brought him into a new field of business. One of his sons, Benjamin, came to Leadville to be clerk at the mine. Later Ben Guggenheim went, as time-keeper, to the Globe smelter at Denver. There he made the acquaintance of Edward H. Holden, the promoter of the Globe Smelting Company, and an enterprising citizen. Holden enlisted Ben Guggenheim's interest in a project to build a smelter at Pueblo, which is seventy miles south of Denver, and at the foot of the mountains in which were the chief sources of ore-supply, notably Aspen and Leadville. Holden persuaded Ben Guggenheim to broach the subject of the proposed smelter to his father. This was done. Meanwhile Meyer Guggenheim,

without a hint from anybody, had become keenly aware of the high charges levied by the smelters on the ore from the A. Y. and Minnie mine, and he had made his usual shrewd enquiries into the business of smelting. To him it looked like the better end of the game. Therefore he was receptive to Holden's proposal. Shortly afterward, Holden, who had disagreed on sundry matters with Charles B. Kountze and Dennis Sheedy, the Denver bankers that controlled the Globe smelter, severed his relations with them. He went to Pueblo, where, with the financial assistance of Meyer Guggenheim, he built the Philadelphia smelter in 1886, the main source of ore being the A. Y. and Minnie mine, together with other mines at Leadville. At this time, and for this purpose, Meyer Guggenheim organized a corporation known as M. Guggenheim's Sons, each of the seven sons obtaining an equal share in the smelting enterprise. The operations of the Philadelphia smelter were conducted at a loss for several years, and it was only after many changes had been made in the staff that the company secured the aid of the best technical advice. The first metallurgist to turn the scale was August Raht. When the business became profitable, the Guggenheims expanded their enterprise by building a smelter at Aguascalientes in Mexico, and, later, another at Monterey, also in Mexico.

In 1899 a consolidation of smelters was formed under the corporate name of the American Smelting & Refining Company, but at this time the Guggenheims had no part in it. The nucleus of the combination was the United Smelting & Refining Company, which owned smelters at East Helena and Great Falls, both in Montana, and the National Smelting & Refining Company's refinery at Chicago. This group of smelters controlled the supply of lead ores from the Coeur d'Alene district, in Idaho, and held a strategic position of decisive importance. Another important member of the consolidation was the Omaha & Grant Smelting & Refining Company, with smelters at Denver, Leadville, and Omaha; and to these were added the plants of the Kansas City Smelting & Refining Company,

the Pueblo Smelting & Refining Company, the Colorado Smelting Company, at Pueblo, the Durango smelter, and the Germania, at Salt Lake City. For a while the Guggenheims were in competition with this big group, which became known as the Trust, a name given 30 years ago to any monopoly, especially if it threatened to be overbearing. A clearing-house for ores was established at Denver, with Franklin Guiterman as manager, and this prepared the way for a merger. In 1901 the American Smelting & Refining Company absorbed the Guggenheim smelter at Philadelphia, their Perth Amboy lead and copper refinery, and their Mexican business as well. For these properties the Guggenheims received $17,500,000 in preferred stock and $17,500,000 in common stock at par. The capital of the American Smelting & Refining Company was increased from $54,000,000 to $100,000,000, whereupon $10,200,000 preferred and common shares in equal parts were sold to the public to obtain more money for improving sundry plants. At this time Daniel Guggenheim, the eldest son, was made chairman of the executive committee, and on the death of E. W. Nash, in 1905, he became president of the company. In the interval the Guggenheims had bought blocks of the common stock, and, with the shares held by friends, they thereby acquired the control. In 1905 the American Smelters Securities Company, a subsidiary company organized by the Guggenheims, purchased the Selby, Tacoma, and Everett smelters, thereby emphasizing the hold that they had upon the mining and smelting industries of the United States and Mexico, although at no time was their control a monopoly. In later years they have speculated in mines on a large scale, and usually with success, but more recently they have decreased their personal participation in the affairs of the big smelting company to become bankers, benefactors, and members of the *haute finance* of New York. It seems a long way from the little A. Y. and Minnie mine in California gulch, Leadville, Colorado, to which we now return.

The immediate result of O'Farrell's discovery was the starting of a lively camp, from which sundry miners carried away from $50,000 to $100,000 each as the reward for their first summer's work.* These placer operations lasted for 15 years, during which period the greater treasures of Leadville lay dormant all around the gold diggings. In the sluice-boxes the miners found lumps of heavy mineral, which they threw aside irritably because they interfered with the saving of the gold, not dreaming that the iron-stained heavy stuff was rich in silver and lead. In 1875 W. H. Stevens and A. B. Wood came over the Mosquito range from Fairplay to build a ditch for conducting water to California gulch. While preparing to do so, Wood examined the hillside and picked up some pieces of lead carbonate. Knowing that this was a carrier of silver, he dug a hole through the surficial debris and uncovered an outcrop of low-grade ore. This was on the south side of Dome hill, on ground subsequently located as the Rock claim. The ore that he found assayed only 27 ounces of silver per ton, but it was rich enough to stimulate systematic search on both sides of California gulch, and on the slope of Iron hill. In 1876 a series of claims was located along the outcrop of the supposed vein, and ore was taken in 1877 from the Rock mine to a smelter, at Malta, that had been built three years before to treat the ore of the Homestake mine, on the Saguache range, opposite the site of Leadville. Stevens persuaded the Harrison Reduction Company of St. Louis to erect a smelter in 1877, and in the following year James B. Grant, a Freiberg graduate, built the plant that became the forerunner of the multifarious metallurgic activities of the Omaha & Grant Smelting & Refining Company. In 1879 Anton Eilers and Gustav Billing built the smelting-plant that in later years became the property of the Arkansas Valley Smelting Company. In 1878 the output of Leadville was worth $3,000,000.

* S. F. Emmons, 'The Geology and Mining Industry of Leadville', U. S. Geol. Survey, *Mon.* XX, p. 77; 1886.

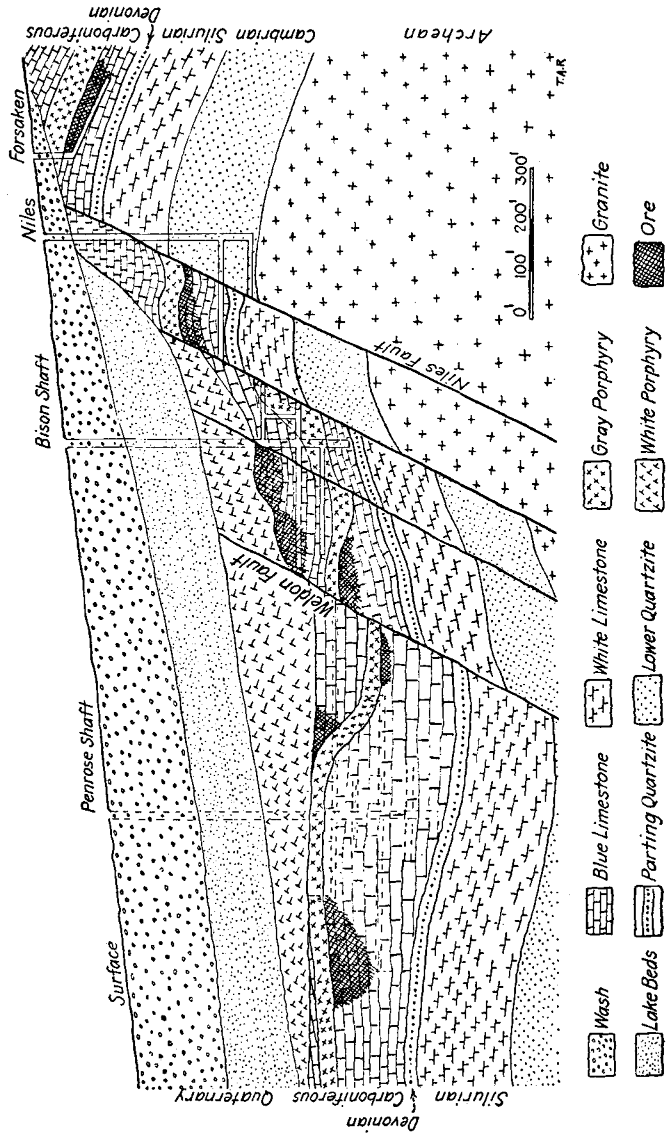


FIG. 9.—Geological section of part of Leadville. (*After Emmons.*)

While these smelters were in course of construction the local supplies of ore were being increased rapidly by further discoveries. The most important was the consequence of pure accident. Two prospectors were grubstaked, or provided with tools and food, by a man named Tabor, who had a store and was the local postmaster. He was to have the half of anything that the two prospectors, Rische and Hook, might find. Among their provisions was a jug of whisky, which proved so inviting that they decided to drink it before they had gone more than a mile from the camp. When they had done so, they concluded that the spot at which they had halted, on Fryer hill, was as good a place as any other for sinking a shaft. At a depth of 30 feet they struck the rich orebody of the Little Pittsburg mine, this being the one point of all others on the hill where the ore lay nearest the surface. Thus Tabor was enriched; but his luck was not yet exhausted. He was asked by the members of a grocery firm with whom he did business at Denver to buy them a prospect. He bought the Chrysolite claim for $40,000 from a notorious person known as Chicken Bill. It was this fellow's specialty to play tricks on the unsuspecting, more particularly by 'salting' claims, that is, by enriching faces of ore artificially. He had not waited until his shaft reached the ore-bearing formation, but had sprinkled rich ore, taken from a neighboring mine, on the bottom of the shaft. Tabor was inexperienced, and was readily fooled. After he had sold the claim, Chicken Bill could not resist the temptation to boast of his performance, a rumor of which reached Tabor's clients, and they, of course, promptly repudiated the transaction. So the mining claim was left in Tabor's hands. Luck was with him; only a few feet deeper, in the same shaft, his men cut into a rich orebody, this time truly in place. After he and his associates had taken $1,500,000 out of the ground, they sold it for a like sum to the Chrysolite Mining Company.

This story of the drunken prospectors, true as it is, must not let us overlook the fact that a month before Tabor's grub-

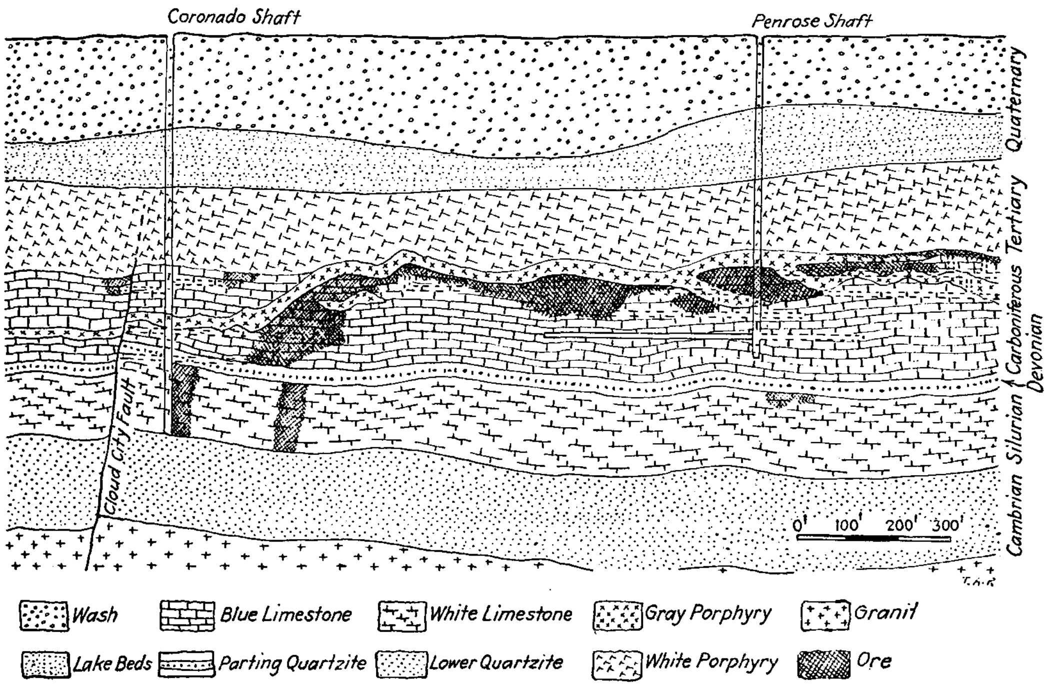


FIG. 10.—Geological section of part of Leadville. (*After Emmons.*)

stakers had found rich ore, the first discovery on Fryer hill had been made by George Fryer in a hole that he sunk north of Stray Horse gulch, where he cut into carbonate ore, and thereby disclosed the great ore-measure that became known as the 'first contact', because it was a replacement in limestone at the contact with an overlying sheet of intrusive porphyry. At first the ore was supposed to be confined to the blue dolomitic limestone (Carboniferous) at or near this contact with the white porphyry, but subsequently ore was found in the underlying white limestone (Silurian) where it was penetrated by, or otherwise near, another igneous rock, called the gray porphyry. This became known as the 'second contact'. Both of these ore-bearing horizons are crossed and dislocated by big faults. Hence it became necessary to the miner to know the extent to which the strata had been displaced, and to ascertain where to seek for the contacts along which the ore had been concentrated. To give this information, S. F. Emmons made a thorough study not only of the geology in the vicinity of the mines but of the entire district within a radius of 10 miles, thereby obtaining a comprehensive view of the structural conditions that had affected the localization of the ore. Through the medium of the United States Geological Survey, he gave the mining community a monograph explaining the distribution of the ore, together with a series of maps that to the mining engineer underground were as charts whereby he steered the course of his exploration; it is not too much to say that, measured even in so commercial a unit as the dollar, they were worth many millions to the operators at Leadville. Moreover, the report by Emmons, published in 1886, taught those engaged in mining throughout the Rocky Mountain region, and elsewhere, how great was the immediate and practical usefulness of a correct geologic diagnosis of a mining district, quite apart from its obvious value in presenting scientific conclusions and in its general educational effect.* The Leadville monograph was epoch-making.

* T. A. Rickard, 'Geology Applied to Mining', *The Mining Magazine*, Vol. XI, p. 126; 1914.

The experience gained at Leadville prompted an eager search for similar deposits elsewhere in Colorado, and resulted in the discoveries that are now associated with the names of Aspen and Rico. The ore deposits of Aspen were investigated by Emmons and J. E. Spurr, both Harvard graduates. Aspen is a locality where the uplifts of the Saguache and Elk mountains converge, so that the sedimentary rocks are squeezed, crushed, and faulted.* Along the faults, and proceeding from them into calcareous rocks, the ores of silver and lead have been deposited, in a manner analogous to that observed at Leadville. Although the porphyritic intrusions are not so large at Aspen, yet intercalations and dikes have played a decisive part in creating conditions favorable to the deposition of ore. The chief ore-bearing horizon is along the upper edge of the Carboniferous limestone, as at Leadville, but in this case the contact is with the overlying Weber shale, also Carboniferous, rather than with porphyry. Where enriched by ore, the shale and the limestone are alike turned into dolomite. Here, as at Leadville, the financial success of mining operations was dependent largely upon the elucidation of a complex system of faults. This was done by the geologist with a skill that the miner acknowledged with gratitude.

The mention of Aspen recalls the name of a mining engineer conspicuous in the development of that district: David W. Brunton. He was manager of several mines at Aspen and he was the engineer of the Cowenhoven adit, which was 2½ miles long, in the driving of which he introduced sundry new methods of pushing through soft ground. Aspen was associated with an early use of electricity in mines, an electric hoist having been placed in the Veteran tunnel in 1888 by William B. Devereux, another distinguished mining engineer. Brunton designed an electric hoist, manufactured by the General Electric Company, for use in the Free Silver shaft. For many years this was the most powerful machine of its kind in the

* J. E. Spurr, 'Geology of the Aspen Mining District, Colorado', U. S. Geol. Survey, Monograph, No. XXXI; 1898.

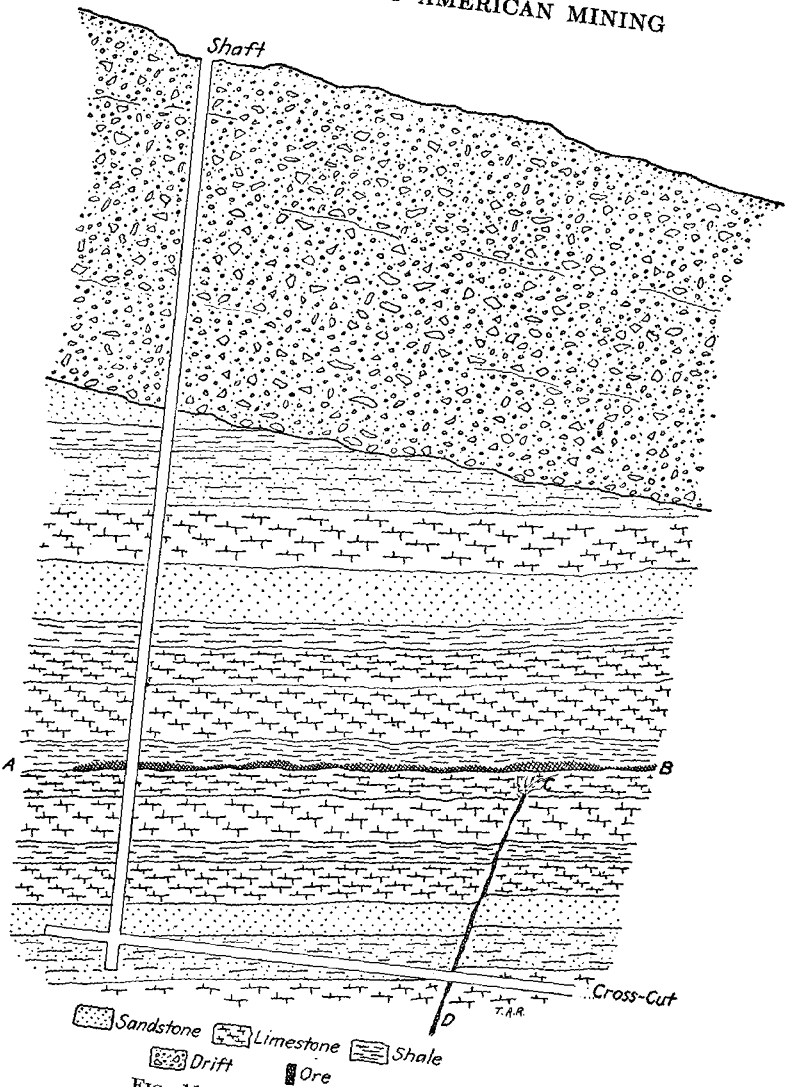


FIG. 11.—Section of Newman hill, Rico.

world.* Brunton was eminently progressive; he was one of the first in Colorado to drive an automobile. Twice (1909 and 1910) he was president of the American Institute of Mining Engineers, and he did honor to the Saunders medal by being the first to whom it was awarded.

At Rico, in the San Juan region, the ore is found also in beds of Carboniferous limestone not far from intrusive masses of igneous rock. The discovery of the first orebody in the Enterprise mine, on Newman hill, admirably illustrates how ore can be found by accident; and the subsequent finding of many other orebodies will serve even better to show how much more effective is the prospecting that is based upon a correct understanding of the local geology.† In 1881 David Swickhimer and his comrades sank a shaft on Newman hill in the expectation of cutting the continuations of veins already worked successfully in sundry claims to the south named the Swansea group. The shaft went through drift all the way for 146 feet. This part of Newman hill has an overburden of glacial detritus, which covers the true rock-surface of sandstone and limestone in which the ore-bearing veins are found. Therefore the veins do not outcrop at the present surface. Another shaft, on an adjoining claim, the Songbird, did reach the lime-shale at 203 feet. Both of these exploratory shafts were in wet ground, and were abandoned. In 1886 Swickhimer, encouraged by developments in the Swansea mine and more than ever persuaded thereby that the veins must extend into the Enterprise claim, recommenced the sinking of his shaft. Despite a heavy influx of water and many mishaps, the shaft was sunk into the lime-shale, where it penetrated rich ore at a depth of 262 feet. The ore was one foot thick; it assayed 2 ounces of gold and 519 ounces of silver per ton. It formed part of a flat lode. In the light of later knowledge, this discovery was a piece of extraordinary good

* T. A. Rickard, 'Interviews with Mining Engineers', p. 78; 1922.

† T. A. Rickard, 'The Enterprise Mine, Rico, Colorado', *Trans. Amer. Inst. Min. and Met. Eng.*, Vol. XXVI, pp. 906–980; 1897.

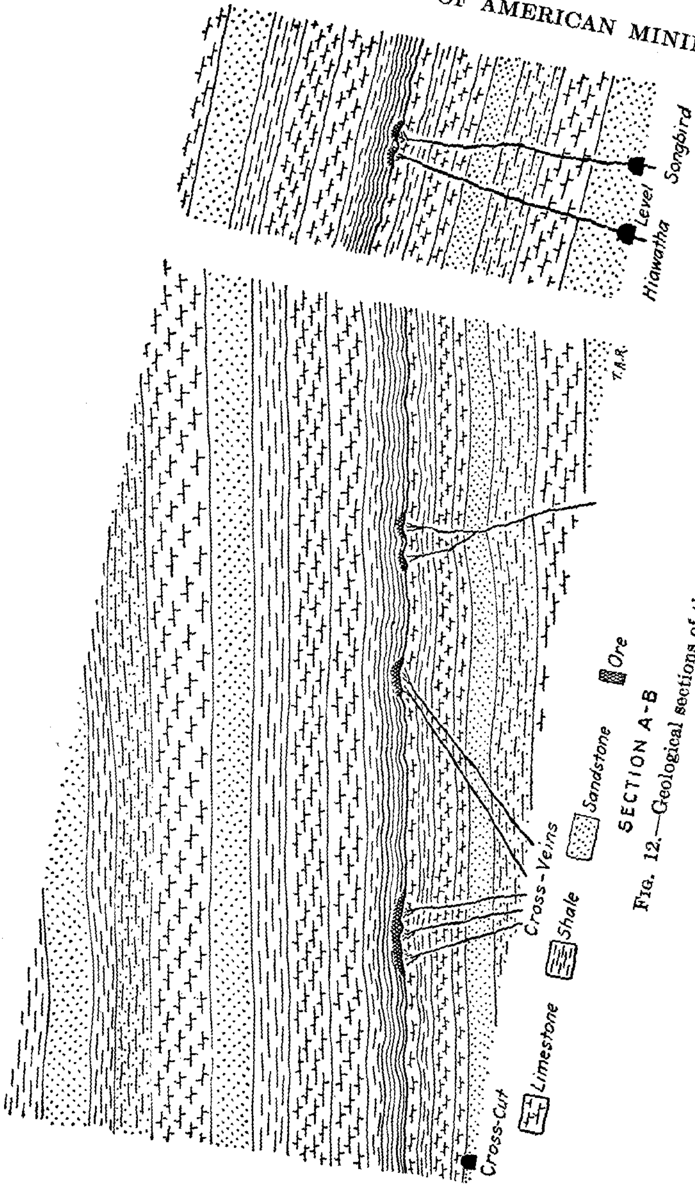


Fig. 12.—Geological sections of the Enterprise mine.

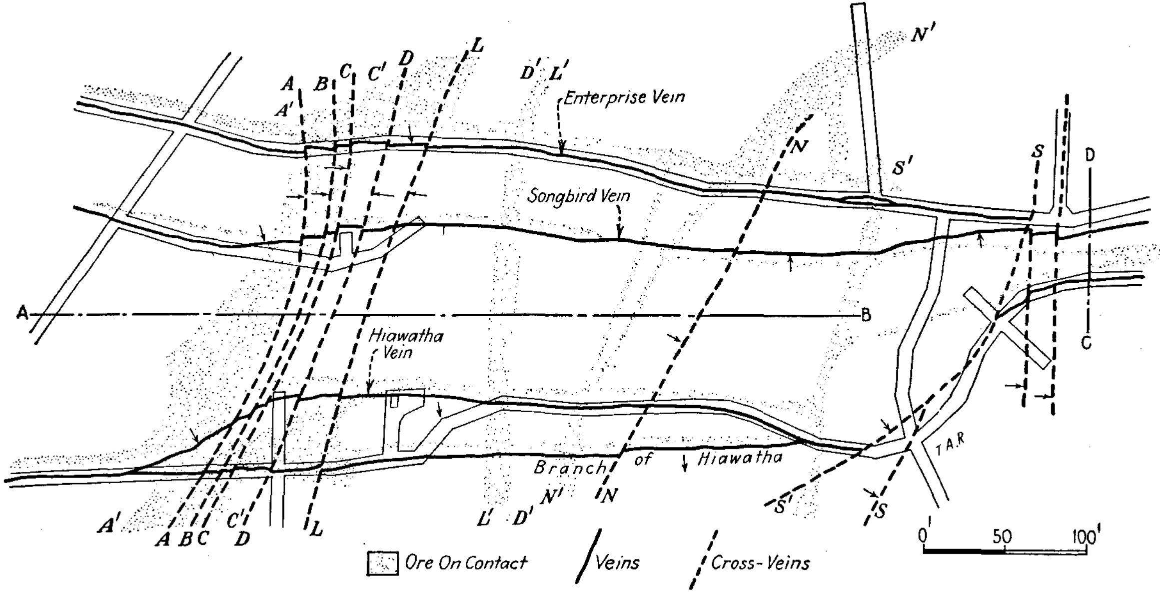


Fig. 13.—Vein system of the Enterprise mine.

fortune, for the orebody proved to be one of the richest in Newman hill, and it would have been missed if the shaft had been sunk 20 feet to the east. Swickhimer thought that the layer of ore was merely a roll or bend on the part of the Enterprise, an almost vertical vein. However, he soon satisfied himself that it was a bedded formation, conforming with the enclosing rock. The shaft was sunk 60 feet below this 'contact', and in a drift run westward the Enterprise vein itself was intercepted at a point 118 feet southwest of the shaft. The ore in the vein was 20 inches thick, and it assayed 3 ounces of gold, with 285 ounces of silver, per ton. Thus Swickhimer, by his intelligent persistence, completed a remarkably successful search for ore, finding not only the vein that was the immediate object of his prospecting, but also an orebody as unexpected as it was rich.

The shale, limestone, and sandstone beds of the Rico series are of Lower Carboniferous age; on Newman hill, as we have seen, they are hidden under a cover of Quaternary drift, the maximum thickness of which is 400 feet. Intrusions of porphyrite, most plentiful at the northern end of the hill, explain the activity of the ore-forming agencies. The mine-workings are largely confined to a vertical range of 200 feet, because the veins do not extend upward beyond the 'contact' and they become barren at an average depth of 100 feet below that horizon. The use of the term 'contact' was borrowed from Leadville; as a matter of fact there is in this case no juxtaposition of an irruptive and a limestone, but a thin layer of pulverulent black shale, which happens to be the remnant of a former bed of gypsum, from 10 to 20 feet thick.* In places this gypsum survives, and contains rich ore. Besides this flat ore deposit we find a double series of upright veins, both of which terminate in their approach to the so-called contact. Just below it, the veins divide into branches, or fan out into stringers; and the interesting fact became disclosed

* Whitman Cross and A. C. Spencer, 'Geology of the Rico Mountains, Colorado', U. S. Geol. Survey, pp. 274–278; 1900.

from careful surveys, made by Rickard, while manager of the mine in 1894, that orebodies along the 'contact' are related to these veins—capping them, as it were. The ore along the plane of the former bed of gypsum exists in narrow bands that correspond exactly to the strike of the tributary veins underneath, and where several veins apex at this horizon the result is a merging of the orebodies into one flat mass, such as that discovered by Swickhimer. Of the two sets of veins, one is barren of ore and is known as 'cross-veins' in distinction to the ore-bearing veins, which are known as 'verticals'. The barren veins have a NW-SE strike and a flat dip; the ore-veins have a NE-SW strike and a nearly vertical dip; they intersect, and the ore-veins are dislocated by the cross-veins. The faulting of the rich veins by the barren ones, and of both by later movements, causes structural complications that the mining engineer must unravel if he is to search for ore intelligently. Obviously a good deal of work and money could be squandered in an aimless search for the broken ends of faulted veins. Indeed, in the early operations in the Enterprise mine the finding of them was haphazard and expensive, even when it was successful.

The mine was opened by means of adits, which also served to test some of the veins in depth. Drifts running northeastward gained distance from the so-called contact, and early gave proof that even the 'verticals' soon became impoverished. Deeper adits and prospecting from shafts in adjoining mines confirmed this unpleasant fact. Yet it was disregarded as long as possible. When Swickhimer, as we have seen, first penetrated into ore on the 'contact,' he thought he had cut a flat vein. Later, when the workings had demonstrated that the ore conformed with the bedding of the shale, the notion was started that Rico had a limestone-shale contact similar to that of Aspen and resembling the ore-bearing zone in the Carboniferous limestone of Leadville. Despite the evidence obtained in the wake of development in regard to the relationship between the ore on the 'contact' and the

veins impinging from below, the Leadville tradition was fostered, until finally there arose talk of a 'second contact' resembling that of the white limestone and gray porphyry at Leadville. Bore-holes and shafts were sunk in the expectation of finding such a zone of ore, but these explorations failed utterly. Analogy is a dangerous mode of reasoning, especially when applied with eyes wilfully shut.

It remains for us to draw two lessons. First from Leadville: there the geological survey of the surface, followed by inductions affording data for the construction of a map exhibiting the rock structure underground, proved of more immediate use to the miner than any theory attempting to explain the origin of the ore deposits. As to the latter, we still engage in disputation; as to the former, we accept the colored chart with gratitude, for the correctness of the mapping has been proved repeatedly by mining operations during the past 50 years. Emmons came to the conclusion that the porphyries were the immediate source of the ore, by the agency of descending waters, which found a soluble medium in the limestones and there effected a chemical exchange that resulted in the deposition of silver and lead minerals in large masses. What may have been the original source of these minerals, he did not venture to say. The later attempts of others to answer this question have usually ended in vague references to a source somewhere "below". I do not hesitate to assert that in directing his scientific investigation toward ascertaining the particular conditions modifying the localization of ore, Emmons did much more for mining than by any theorizing upon the origin of that ore. He was thoroughly in touch with the engineers in charge of the mines, and he knew the sort of guidance that would help them most. Such guidance he was enabled to give them. Whatever may be the primary source of the ore, it is the *last* process of concentration that has formed the orebody as found today by the miner. He wants to know what conditions have modified the final concentration, so that he may search for such favorable

conditions as a preliminary to finding the ore itself. He asks the geologist to tell him where the ore is likely to be *now*, not where it was formerly or whence it came. The one is merely interesting; the other is of immediate economic importance.

At Rico likewise the recognition of the structural relations was more directly useful to the miner than any theory explaining the genesis of the ore deposits. For instance, it was interesting to learn that the so-called contact marks the position of a former bed of gypsum, but it proved much more important to the mining engineer to recognize the existence of a definite horizon above which the veins did not extend and along which they were connected with a layer of rich ore. The further observation that this ore existed in bands corresponding to the strikes of two systems of veins underneath was more to the point than any discussion of the genetic connection between the ore deposits and the porphyrite, which had penetrated the Carboniferous strata and had been probably a prime factor in giving life to the thermal waters that had circulated along the vein-fractures and along the gypsum contact. Finally, the detection of a rule of faulting, however difficult to explain, was more helpful to the mine-manager than scientific ruminations concerning the source of the ore, the age of the deposits, or the paleontology of the rocks enclosing them. Both Leadville and Rico afford notable examples of the fact that in ascertaining the structural relations of the ore deposits, the geologist can give the miner the most positive aid; as was early realized by Emmons,* who, by his consistent effort to follow this line of research, was enabled to give geology an economic function previously unknown in metal-mining.

This was appreciated by the time the Cripple Creek district became an important goldfield, in 1891, and thereby unexpectedly justified the expectations of an earlier day. Pike's Peak, the summit of which rises to 14,107 feet above sea-level,

*S. F. Emmons, 'Structural Relations of Ore Deposits', *Trans. Amer. Inst. Min. and Met. Eng.*, Vol. XVI, pp. 804–839.

had served as a landmark for two mining excitements, and in the end the noble mountain was fated to cast its cool shadow upon a hectic mining centre. In the rush to California, after 1848, the adventurers that came westward across the plains shaded their eyes to catch the first glimpse of the beacon mountain, which Lieutenant Zebulon Pike had reconnoitred in the first years of the century. The immigration that was destined to dispossess the Indian and the buffalo was guided by this snowy summit in the last stage of the long trek from the Missouri river to the Rocky Mountains. Ten years later the rumor of gold being found in this part of the country caused a stampede that was frustrated in its immediate objective, as we have seen, although it led subsequently to the discoveries of Gilpin and Leadville. To these and other districts the prospectors went during the next two decades; and so the silence of the pine-clad hills around Pike's Peak remained unbroken by the blow of pick or hammer.

Suddenly, in the spring of 1884, rumors were circulated concerning a wonderful discovery on the southern slope of the Peak. During the darkness of an April night a horde of prospectors stole hurriedly away in obedience to vague hints that had been scattered among the *habitués* of the saloons in Leadville and neighboring mining-camps. Each party aimed to be the first on the ground. The dawn of the next day found an excited crowd of four thousand men gathered together at the foot of Mount Pisgah. The incident became known in local history as the Mount Pisgah fiasco.* Among the hills that cluster around the southern base of Pike's Peak is a dark cone of phonolite standing apart from his smaller brethren. This is Mount Pisgah. In 1884 the miners that had assembled there were unable to find gold in workable quantity save in the prospect holes made by the original locators. Whether they had sold their claims, we are not informed. Artificial enrichment, or salting, was suspected; the man that

* T. A. Rickard, 'The Cripple Creek Goldfield', *Trans.* Inst. Min. and Met., Vol. VIII, p. 50; 1899.

had instigated the rush was conspicuous by his absence; and a supposed accomplice is reported to have been caught with a bottle of yellow stuff in his pocket. It was not whisky, but its sometime antidote, the chloride of gold. Suspicion seemed justified. Angry feelings found vent in threats of lynching, but in the failure to lay hands upon the actual perpetrator of the fraud, the affair ended in a big picnic and a general drunk. A little digging had been done, one or two quartz veins had been disclosed, but the comparative poverty of the ore only added bitterness to the general disappointment. The crowd dispersed as quickly as it had come. The hillsides resumed the quiet aspect of the cattle range for which they seemed best fitted. The vicissitudes of mining are proverbial. No locality illustrates the fickleness of fortune more forcibly than Cripple Creek, which later sprang into productive life on the very scene of the Mount Pisgah fiasco; from the summit of that discredited hill a geologic Moses might have been vouchsafed the vision of a promised wealth in gold and silver, but even when at last genuine discoveries were announced, in 1891, there was no rush thither. It remains to add that on the top of Bull cliffs, a name reminiscent of the fact that the district was formerly given up to the ruminating herd, there was found a shallow shaft dug in the days of the first Pike's Peak excitement. That shaft was near not one but several mines subsequently so rich as to make fortunes for many.

The discoverer of Cripple Creek was Robert Womack, the owner of a small ranch in the district and a prospector at intervals from 1880 onward. The cowboys and herdsmen looked good-naturedly at Bob's digging, but did not consider it of any consequence. In 1890 he found a promising vein—small, but rich—in Poverty gulch, and sank a shaft 48 feet on a claim that he named the El Paso. This became the Gold King mine when Womack optioned it for $5,000 to F. F. Frisbee, and he in turn transferred it, at a profit, to Lennox & Geddings, of Colorado Springs, which is 20 miles

eastward from Cripple Creek, and on the opposite side of Pike's Peak. These transactions caused hardly a ripple of interest in local mining circles, because the Pike's Peak area had gained a bad name: moreover, another excitement, at Creede, in southwestern Colorado, diverted attention at this time.

It was Stratton's discovery that put Cripple Creek on the map.* W. S. Stratton, a carpenter by trade, had been in the habit for many years of prospecting when not engaged at his regular work; he had learned the use of a blowpipe and had acquired the elements of mineralogy; in short, he was an energetic and intelligent man. During the early part of 1891 he was searching for cryolite, a mineral from which aluminum is extracted, and had pitched his tent on the western slope of Pike's Peak. In May, while at Colorado Springs, he met Frisbee, who showed him some assays of ore that had come from Cripple Creek. Thereupon Stratton moved thither and went to see the work done by Womack. Among others that were prospecting in the vicinity was an old mountaineer named Dick Houghton. One day he met Stratton and showed him a piece of ore that looked like galena, so Houghton said. Stratton, however, demurred; it was not the sulphide of lead. They went together to Stratton's tent, where a blowpipe test was made. Under the hot flame the mineral yielded a button of gold. Neither knew that it was a telluride of gold, probably calaverite or sylvanite. Cripple Creek became famous for its lustrous tellurides, both of gold and of silver, minerals of a kind previously but rarely known to the miner, although made familiar by subsequent discoveries in other parts of the world, notably at Kalgoorlie, in Western Australia. It is not recorded who was the first to recognize the tellurides of Cripple Creek,†

* T. A. Rickard, 'Two Famous Mines', *Mining and Scientific Press*, Vol. CIII, p. 765; 1911.

† Probably the credit belongs to Richard Pearce, a keen mineralogist, then residing at Denver. R. Pearce, 'The Mode of Occurrence of Gold in the Ores of the Cripple Creek District', Colorado Scientific Society, *Proc.*, Vol. V, p. 7; 1894.

but there is a story that a miner made a camp fireplace with some pieces of rock and that the heat of his cooking operations caused a part of his hearth to sweat gold, which means that the ore in the rock was roasted, the tellurium being released as fume, leaving globules of gold behind. Such an accident is not unlikely.

Stratton located a claim next to Houghton's, and continued to roam over the hills in search of something better. On the sixth of June he moved his tent to the foot of Battle mountain, a grassy slope, where he, in company with a man named Troutman, found a piece of loose rock full of gold; but the source of this rich 'float' they could not find. An old ranchman, Billy Fernay, came along at this time and showed Stratton some float that he had found on the hillside, whereupon they located a claim in the joint names of Stratton, Houghton, and Troutman. Next day Stratton examined the ground, and, having found a vein, tried to make the trend of it accord with the line of the ridge, for he had an idea that the rich ore would be confined to veins having a north-south direction. It is not unusual for prospectors to have such notions fixed in their minds. This led him down the hill to a bold outcrop of granite. The outcrop, in dikelike projection above the surface, had been seen by many; a path from one ranch to another ran close to it, and all the cattle-men that had any fancy for prospecting had looked at it, only to condemn the rock as worthless granite. Fernay drew Stratton's attention to this outcrop, but he, like the others, thought it most unattractive. On examining the rock he noted the absence of any familiar metallic mineral and an entire lack of the vein-quartz with which he was accustomed to associate the occurrence of gold. He was mistaken; the granite was much decomposed, it was impregnated with iron oxide, and it contained vesicular quartz in which plenty of fine gold lay hidden; in brief, to a prospector of adequate experience it was a most promising veinstone. Stratton found gold by panning the debris on the hillside near this granite comb, but he

was unable to trace the gold to a source in the kind of ore he was seeking. He took loose fragments of porphyry, the prevailing formation, to Colorado Springs for assay, but the results showed only three or four dollars per ton. It occurred to him then that the granite outcrop must be the lode from which the gold was derived. Acting on the impulse, he returned quickly on horseback and celebrated the day—the Fourth of July—by locating two claims, the Washington and the Independence. Some pieces of the outcrop were broken, and Troutman took them to Colorado Springs to be assayed. He returned in haste next day with an assay-certificate proving the ore to contain 19 ounces—$380—per ton! It was a *bonanza.*

From 1891 to 1898 the output of the Independence mine was worth $3,985,440, and the profit to Stratton was $2,402,164. In 1899 the mine was transferred to a London company and became the sport of reckless promotion. Including his dividends, Stratton received $10,000,000 from the English promoters before his interest was terminated. From 1898 to 1904 the production of the mine was $11,046,947, from which $4,142,738 was paid in dividends. Altogether the Independence mine yielded $21,061,585, of which $7,393,654 was distributed in dividends, to which must be added sundry profits to the promoters, lessees, and ore-stealers, equivalent to at least $3,000,000 more. Stratton died in 1901, ten years after his discovery. By that time the Cripple Creek district had yielded $125,000,000 in gold.

CHAPTER VII

LEAD MINING IN THE MISSISSIPPI VALLEY

The Mississippi river was discovered by French explorers that came southwestward, by way of the Great Lakes, from eastern Canada. Vignan, Joliet, De Champlain, and others of the French pioneers in the first half of the seventeenth century, dreamed of a short cut to China by means of the great waterways they explored. In a geographical book published in London in 1726 by Daniel Coxe an account is given of "a new and curious discovery and relation betwixt the river Meschachebe [Mississippi] and the South Sea, which separates America from China, by means of several large rivers and lakes". Louis Joliet, a fur-trader, and Jacques Marquette, a Jesuit missionary, reached the Mississippi and paddled their canoes on its broad waters on June 17, 1673.* They descended the river as far as the entry of the Arkansas tributary, and then returned overland to Canada, being deterred from going farther south by reason of Indian hostility. Several years later Robert de La Salle, a French trader, starting from Quebec, went westward to Lake Michigan and thence to the Illinois river, which he and his comrades descended in their canoes to the junction with the Mississippi, and then followed it to the sea. They reached the Gulf of Mexico on April 9, 1682. Thus the great central waterway of North America was made known.

These French-Canadian *voyageurs,* or boatmen, traded with the Indians for furs in the Upper Mississippi valley, and when in need of bullets they noticed the outcrops of lead ore, from which, probably in the last decade of the seventeenth

* James W. Thompson, *Historical Collections of Louisiana,* part 2, p. 284; 1850.

century, they began to extract the metal in a crude way for the purpose of making ammunition. It is probable that the first trader to teach the use of gunpowder to the tribesmen on the upper Mississippi was Jean Nicollet, who came from Ottawa to Green Bay, on Lake Michigan in 1634, and had dealings with the Winnebago Indians of Wisconsin. Radisson and Groseilliers, who followed in the wake of Nicollet, ascended the Fox river and accidentally re-discovered the Mississippi; they heard of lead ore in 1658 when among the Bœuf [buffalo] Sioux,* probably in the vicinity of Dubuque, in Iowa. Joutel, who was in this region as early as 1687, says in his journal of 1713 that "travelers who have been at the upper part of the Mississippi affirm that they have found mines of very good lead there".† Louis Hennepin's map of 1687 shows a lead mine near the present site of Galena. Father Hennepin was a companion of La Salle.

The French were aware of the value of the lead ores, and questioned the Indians concerning them. Although the aborigines regarded minerals in a superstitious way, they had enough of cupidity to show the traders where ore could be obtained when themselves adequately rewarded for such assistance. The white trappers had introduced the use of guns among the Indians and had taught them how to hunt for the fur-bearing animals on a commercial scale; in consequence lead became of economic value both in the making of bullets and as an article of trade.‡

The finding of copper was also reported by the early explorers, but this probably was native copper carried in the Glacial drift from the Lake Superior region, or it was a green earth such as fooled Pierre le Sueur. He journeyed from Mackinac by way of the Wisconsin (which the French called Ouisconsin) river in 1683 and trafficked with the Sioux

* *Wisconsin Historical Collections*, Vol. XI, p. 93; 1893.

† Reuben G. Thwaites, *Collections of the State Historical Society of Washington*, Vol. XIII, p. 271; 1895.

‡ Reuben G. Thwaites, 'Wisconsin', p. 155; 1908.

Indians at the headwaters of the Mississippi. He reported the finding of certain lead ores and colored earths. In 1697 he obtained permission to exploit these deposits, and in 1699 he arrived in Louisiana with 29 miners, whereupon he was aided by D'Iberville, the Governor, in his expedition to these supposed valuable deposits. Le Sueur went to the upper Mississippi and took 3000 pounds of supposed copper ore, which he loaded into his canoes and brought to Biloxi in 1702, but on arrival in France the cargo of mineral proved to be a worthless green sand. This fiasco ended his career.

The pioneer miner of the Mississippi valley was Nicolas Perrot; he may have come to these parts with Le Sueur. According to one account, Perrot, in 1690, when at Green Bay, on Lake Michigan, was presented with a lump of lead ore by a Miami chief. La Potherie says that the chief gave Perrot information concerning the source of the ore, and Perrot shortly afterward went thither: on the Mississippi, below the Wisconsin river, in the country of the Sioux. He found "the lead hard to work because it lay between rocks and required blasting; it had very little dross, and was already melted".* These particulars indicate that the mineral was galena. The diggings probably had already been started by the Indians, on the initiative of the fur-trader, and they had found unoxidized ore that looked so metallic that it appeared to have been melted by some natural process. According to another account, Perrot said that "he taught the Indians how to cut the ore from the rocks" and that by melting, it was reduced one-half.† Later, when the diggings became deeper, the Indians learned to make an inclined plane; along this slope they carried wood to the working face, where they made a fire, to heat the rock, on which afterward they threw water, so as to cause it to crack and disintegrate.

* Bacqueville de la Potherie, 'Histoire de l'Amérique Septentrionale', Vol. II, p. 251; 1753.

† E. H. Blair, 'Indian Tribes of the Upper Mississippi', Vol. II, p. 74; 1911.

Then, with a queer assortment of implements, such as stag-horns, hoes, and old gun-barrels, they dug the mineral. Most of the labor was performed by the squaws, who removed the broken ore in birch-bark 'mococks', or panniers, and carried it to a crude hearth built of logs, which were laid on a slope. The wood was set on fire, and as the lead melted and ran down, the Indians scraped a place into which the molten metal settled so as to form flat ingots, in which shape it was transported down the great river.* Perrot's trading-post, built at this time, was on the east bank of the river, opposite the site of Dubuque.

In 1699 Le Sueur, as we have seen, ascended the Mississippi intent upon exploring the lead mines in behalf of the French king. He worked some ore in the now deserted Perrot mine, and also near Potosi, in Wisconsin, but the results were not satisfactory, so he returned to France without developing the industry. Penicault, who accompanied Le Sueur in his last expedition up the Mississippi in 1700, says that "these mines are known to this day by Perrot's name".† The itinerary of this voyage of Le Sueur, as given in La Harpe's history of Louisiana, written in the early part of the eighteenth century, states that Le Sueur found lead on the banks of the Mississippi not far from the present southern boundary of Wisconsin, that is, in the vicinity of the mining districts of Galena and Dubuque. Charlevoix‡ says that the first discovery of lead in the Mississippi country was made by Perrot in 1692, and he adds that in 1721 the mines still bore Perrot's name. According to him they were above the Des Moines river.

It is said that the Indians sold some lead of their own smelting to French traders at Peoria in 1690.§ If this means

* W. R. Smith, 'History of Wisconsin', Vol. III, p. 353; 1854.

† B. F. French, *Historical Collections of Louisiana and Florida*, p. 68; 1869.

‡ Pierre F. X. de Charlevoix, 'Histoire de la Nouvelle France', Vol. III, p. 397; 1744.

§ W. H. Pulsifer, 'Notes for a History of Lead', p. 82; 1888.

that they knew how to smelt the ore before they were shown how to do so by Europeans, it is highly improbable. There is no reason to believe that the aborigines understood the art of smelting. In the burial mounds of the Mississippi valley the only lead relics are in the form of crystalline galena,

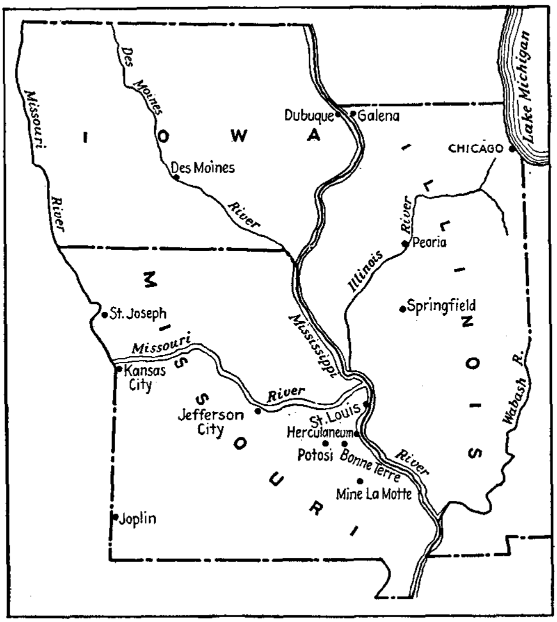


FIG. 14.—The lead districts of the Mississippi region. (*Reproduction licensed—base material copyrighted by Rand McNally & Company.*)

sometimes slightly cut, and their exterior completely oxidized.* Such pieces appear to have been kept as a curiosity. The aborigines of this part of America did not know how to smelt any ore; they did not know even how to melt the native metals that they found, such as gold, silver, and copper, or to shape them by casting in a mould. All their metallic artifacts

* F. W. Putnam, *Reports of the Peabody Museum*, Vol. III, pp. 173 and 426; 1885–1886. Also Charles Peabody, *Peabody Museum Papers*, Vol. III, p. 48; 1904.

were made simply by hammering with stone. In 1766 Captain Jonathan Carver, a colonial Indian fighter, found lead in abundance at the Blue Mounds, and he tells us that the Indians in the surrounding country were seen by him to be in possession of pieces of galena, which they had obtained as 'float', that is, they had picked it up from the surface without digging; and they apparently were incapable of putting it to any use. They kept it as a pretty thing, a curiosity, or, perhaps, as a mascot, as was done by the Indians in the Lake Superior region with the lumps of native copper that they found.

The French, as we have seen, introduced fire-arms among the Indians and showed them how to shoot the fur-bearing animals, whereupon the Indians soon imitated their patrons by digging lead ore and making bullets. The first metallurgists in the Mississippi valley were the hunter and the Indian; they gathered the ore exposed at the surface or dug shallow trenches to obtain more of it; then they smelted the ore by making a fire in an old stump, in the hollow of a fallen tree, or in the camp-fire itself, which, the world over, was the primitive metallurgic hearth. From the ashes they picked the little lumps of lead that had been reduced from the ore by this haphazard operation. By such crude methods they advanced to the use of the log-hearth, which was simply a trench dug in a hillside that was filled with logs on which the ore was thrown. The fire would be started in the evening, and in the morning the lead would be found at the bottom of the trench, where it had consolidated into shapeless lumps or had trickled into small holes that had been scratched in the earth under the logs. Later these frontier metallurgists found it convenient when casting their lead to make a hole in the ground in the shape of a brick, and in the centre of this mould they placed a stick, so that when the lead ran into the hole from the ore that had been reduced by a wood fire it cooled to an ingot with a perforation in it; through this perforation they drew a rawhide rope, to facilitate transport,

for it could then be easily swung either on the shoulder of a man or on the back of a horse.*

The scene now shifts southward to Missouri.

In 1712, during the reign of Louis XIV, a mining concession was granted to Antoine Crozat in the Louisiana territory, which belonged to France and at that time extended from the Carolinas to New Mexico, with an indefinite limit northward to the headwaters of the Mississippi. In 1717 Crozat retroceded his rights to the French Crown, whereupon the privilege of working mines and of engaging in commerce within the territory was granted to *La Compagnie de la Louisiane ou d'Occident*, known generally as the Company of the West, the promoter of which was the notorious John Law, a Scottish financier, whose flamboyant enterprise, when it failed completely in 1720, went down in history as the Mississippi Bubble. Among the adventurers that penetrated into the country of the Illinois Indians at that time was Philippe Renault, the son of an iron-founder at Consobre, in France, and therefore probably a man possessed of some technical knowledge. He was at the head of a syndicate subsidiary to the big company, and his task was to initiate mining operations in the northern part of Louisiana, in the upper valley of the Mississippi. He was designated the Director General of the Mines of the Royal India Company in Illinois, this last name at that time including much more than the present State of Illinois. Renault left France in 1719, taking with him 200 artificers and miners, well provided with tools.† On his way to New Orleans he touched at the island of Santo Domingo and purchased 500 Negroes for working the mines. From New Orleans he proceeded, in 1720, to Kaskaskia, which was one of the earliest outposts established by the French fur-traders coming southward from the Great Lakes. Renault fixed his headquarters at

* Robert Hunt, 'British Mining', p. 121; 1884.

† Henry R. Schoolcraft, 'A View of the Lead Mines of Missouri', p. 15; 1819.

Fort Chartres, and from there he sent forth his exploring parties, some of which were led by Antoine de la Mothe Cadillac, whose name survives* in that of the district in the Ozark hills of Missouri known to this day as Mine La Motte, at the headwaters of the St. Francis river. His name is memorialized also in that of a standard automobile, manufactured at Detroit, which city he founded.† The members of this French expedition apparently knew little about smelting, for Charlevoix, who was in the region during 1721, says that one of the party, the Sieur de Lochon came thither as a smelter expert in 1719, and that he tried to extract silver out of a lead ore, but, even after four days of laborious effort De Lochon succeeded in obtaining only two drachms of silver out of a pound of ore, and even this, it was suspected, had been added by a practical joker. Later he recovered fourteen pounds of bad lead from more than a ton of ore, whereupon, highly disgusted, he returned to France. It was left for Renault himself to direct the real work of development. At first he was much disappointed in his confident expectations of finding gold and silver, whereupon he turned energetically to the mining and smelting of lead ores. "In the month of June last", says Charlevoix, "Renault found a bed of lead two feet in thickness, running to a great length over a chain of mountains, where he has set his people to work."‡ The lead he produced was carried on pack-horses to New Orleans for shipment to France. Renault appears to have done well until the Indians crippled his operations, but in 1742 he returned to France, taking most of his workmen with him, and selling the slaves before his departure.

In 1763 François Vallé resumed work at Mine La Motte, and built a block-house to protect his men from the attacks

* Also in Cadillac, a city of 9570 inhabitants, in Michigan.

† Louis Hennepin, 'A Description of Louisiana', p. 61, as translated by J. G. Shea; 1880.

‡ Pierre F. X. de Charlevoix, 'Journal of a Voyage to North America', Vol. II, p. 219; 1761.

of the Chickasaws, but, despite this defence, the Indians captured the post in 1769, during the absence of Vallé, and killed his son. Work was abandoned at intervals, punctuated by Indian raids, to be resumed successfully in 1782. Captain Henry Gordon states that in 1766 the French had "large boats of 20 tons, rowed with 20 oars, which go in seventy odd days from New Orleans to Ilinois. These boats go to the Ilinois twice a year, and are not half loaded on their return; was there any produce worth sending to market, they could carry it at no great expence. They, however, carry lead, the produce of a mine on the French side of the river, which yields but a small quantity, as they have not hands to work it".* The reader will note that the spelling of the original is faithfully reproduced.

In 1770 the lead of the miner, next to the peltry of the fur-trader, was the most valuable article of export from this region. It served also as currency.† Meanwhile, in 1762, the eastern half of the Mississippi valley had been ceded by France to England and the western half to Spain. Under the new regime the search for mines was resumed and some of the old diggings were re-opened. In 1763 an important discovery was made by a Frenchman named Burton, or Breton, formerly with Renault; while pursuing a bear he stumbled upon a rich outcrop of lead at a place that became known at first as *Mine à Burton*, and later as Potosi. In 1798 a concession to Moses Austin brought a man of real technical ability to the mines. Austin built a reverberatory furnace and a shot-tower at Herculaneum, of which he was the founder. However, the output of lead was small; Mills estimates the total output of Mine La Motte from 1723 to 1804 at 8000 tons.‡ In 1916 some old tools were found in

* Thomas Pownall, 'Topographical Description of North America'; 1776.

† Reuben G. Thwaites, 'How George Rogers Clark Won the Northwest', p. 312; 1903.

‡ James E. Mills, 'Geological Report on the Mine La Motte Estate', New York, 1877.

the abandoned workings of Mine La Motte; the most interesting of these was a three-pronged grappling-iron used for displacing and pulling oxidized and partly oxidized ore out of cavities. Some small car-wheels made of solid wood were also found; these were made of the *bois d'arc*, bow-wood, known as the osage in the Mississippi valley, where it is indigenous. The evidence of wear on these wheels indicated the use of a track made of wooden rails. Another interesting relic consisted of a few bars of lead cast in the shape of a horse-collar, so made as to be carried on a mule's shoulder in course of overland transport.

Now we return to the Upper Mississippi region, where Perrot started mining in 1692. For a long time not much was done in these parts, because the discoveries southward in Missouri proved more attractive. Le Guis in 1743 gives an account of the methods used by twenty miners then at work in the Fever River region,* which included the adjacent parts of the present States of Wisconsin, Illinois, and Iowa. He says that these men were "a fast lot", and that every man worked for himself, "getting enough to earn him a bare existence for the rest of the year". That does not sound to us as anything extraordinary; it is typical of the miner's life. Le Guis describes their method of smelting, which shows a little improvement on the earlier log-hearth. First they cut down two or three large trees and divide them into logs five feet long. They then dig a bowl in the ground and place three or four of the logs over it. More logs, arranged so as to make a boxlike enclosure, are superimposed, and into this enclosure they shovel the ore, which is then covered with more fire-wood. The fire is started underneath; the logs burn; and the mineral is partly melted. The operation may have to be repeated three times before the ore is adequately reduced. The lead, falling into the bowl, is found in a lump, which is subsequently re-melted into bars weighing

* Joseph Wallace, 'The History of Illinois and Louisiana under French Rule', p. 274; 1893.

from 60 to 80 pounds, in order to facilitate transport to Kaskaskia. This is done by horses, "which are quite vigorous", says Le Guis; "four or five bars of lead is a load for a horse"; and this seems by no means excessive. Our informant concludes by stating that "in spite of the bad system these men have to work, there has been taken out of the La Motte mine 2500 of these bars in 1741, 2228 in 1724, and these men work only four or five months in the year at most". Their system did not warrant contempt; it was not much improved until the introduction of the Drummond blast-furnace in 1836—a century later.

In 1774 a French-Canadian named Julien Dubuque discovered lead ore near the site of the city, in Iowa, that now bears his name. He was a most enterprising trader and had the good fortune to be liked by the Indians, with whom he lived on the most friendly terms; not only did he employ many of them to aid him in finding ore and in digging it, but he married the daughter of a chief. From the west side of the Mississippi he crossed to the eastern bank of the river and started new diggings there also.* At a full council of the Sauk and Fox Indians held at Prairie du Chien in 1788 he was granted formal permission "to work lead mines peacefully and without prejudice to his labors"; and thereafter for many years he and his agents mined for lead in northeastern Iowa and northwestern Illinois. The grant from the Indians was confirmed by Carondelet, the Governor of Louisiana, in 1796; it is said to have extended for seven leagues along the Mississippi and to have been three leagues wide. In a statement made by Dubuque himself to Major Zebulon M. Pike in 1805, he claimed that his mines on the west side of the Mississippi were yielding about 30,000 pigs of lead annually. He waxed rich on lead and peltries, both of which he shipped to St. Louis, making journeys thither twice a year. Dubuque employed his Indian friends in prospecting, and if they found anything he sent Canadians and half-breeds to test the dis-

* Dubuque and Galena are 12 miles apart.

covery, although he was content sometimes to let the Indians dig the lead ore themselves on the understanding that they would bring the product to his trading-post on the river. In this manner he dominated the entire lead region of Iowa, Wisconsin, and Illinois before American settlements were made.* When Dubuque died, in 1810, his Indian friends buried him in a leaden coffin, and they refused to let any other European operate the mines. Schoolcraft, writing in 1819, remarks that "the Sacs [Sauks] and Foxes are still in possession of the mines of Prairie du Chien", and they continued to claim them until they were removed from the district in 1832. After Dubuque's death, the Upper Mississippi lead deposits were neglected until 1821, when the attention of Americans was first drawn to the rich lead ores in this part of the country.†

The Indians with whom Dubuque lived had learned from earlier Europeans how to mine and smelt the ore. As a rule they gathered only the ore exposed at the surface, although in places they dug into the hillside for a short distance.‡ When they reached hard rock they built a fire, and when the face had become well heated they dashed cold water upon it, so as to cause it to crack. This is the 'fire-setting' method common to all primitive miners, and in vogue in Europe even after the introduction of explosives. For tools, the Indians used staghorns, many of which have been found in the abandoned diggings. The staghorn likewise was the pick of the primitive miner in Europe. In Dubuque's time the Indians obtained iron implements from the traders to whom they sold the lead. The mining was done chiefly by the squaws, and a few old men. No warrior demeaned

* Reuben G. Thwaites, 'How George Rogers Clark Won the Northwest', p. 318; 1903.

† R. D. Irving, *Trans.* Amer. Inst. Min. and Met. Eng., Vol. VIII, p. 498; 1880.

‡ Reuben G. Thwaites, Report of the American Historical Association, 1893, p. 194.

himself to such undignified labor. When they dug to any depth below the surface they did not sink vertical pits but inclines, up which the ore, in deer-skin bags, was dragged by means of long thongs of hide. A rich vein is said to have been discovered in 1780 by a squaw of Peosta, a Fox warrior. Even so late as 1810, we are told by John Shaw that the squaws carried the mineral in sacks on their heads to the smelting-places; he claims to have loaded 70 tons of lead in his boat, this being the first boat-load of the metal to be taken from Galena.*

Dubuque's Indian associates, under his guidance, smelted the ore in an improved trench furnace. A hole, two feet deep, and as wide at the top, was dug in the face of a hillslope; this hole tapered like a mill-hopper and was lined with flat stones. Across the lower end, which was about eight inches square, narrow stones were placed gratewise. A channel, a foot wide and deep, was dug from this crude furnace to a depression in the ground that served as a mould. The channel was filled with dry wood and brush, which, when ignited by the molten lead, served to maintain its liquidity. The flat ingots, called *plats* (or plates), by the French, weighed about 70 pounds apiece, or about the same as the pigs of later days.

When Schoolcraft visited the lead mines of Missouri in 1818, he found the log-furnace still in use.† It consisted of a steeply inclined hearth, on a hillside; it was enclosed by a brick wall on two sides and at the lower end, where the wall was seven feet high, through which an arched opening admitted air. The furnace had no roof. Three large oak logs were rolled into the hearth from the back and rested on ledges so as to occupy the full width of the furnace; then small split logs were set up, after which the ore (chiefly galena) was

* *Collections of the State Historical Society of Wisconsin,* Vol. II, p. 228; 1856.

† Henry R. Schoolcraft, 'A View of the Lead Mines of Missouri', p. 94; 1819.

shoveled into the furnace, so as to fill it. More logs were laid on the ore until it was completely surrounded by the fuel. The smelting operation was started with a gentle heat, which was raised gradually. Without any clear notion of what they were doing, the effect was first to roast a portion of the sulphide ore, forming lead sulphate and lead oxide, and when the temperature was increased these products reacted with the unoxidized galena so as to produce metallic lead and sulphur dioxide, the latter going forth as fume while the metal found its way into a hole prepared to receive it. The conditions were not such as to complete the necessary chemical reactions, and the recovery of the lead therefore was defective. From 24 to 36 hours was required for the smelting, and the yield represented about half of the lead content. Small lumps, only partly reduced, fell into the wood ashes, or, if the heat was sufficient, they mingled with the slag. This refuse, called the 'lead ashes', after being picked for a few lumps of clean lead, underwent washing and then was smelted with flux (chert or sand) in an inclined reverberatory furnace (also on a hillslope) introduced from Virginia, the yield being an additional 15 per cent, making the recovery about 65 per cent in all.

Schoolcraft, a scholarly Indian agent of the Federal Government, re-visited the Mississippi valley in 1820, and went to the Dubuque mines,* where the work was being done by the squaws, who were provided with hoes, shovels, and pickaxes by the traders. With these tools they dug trenches to a depth determined by the hardness of the rock. There were no shafts; instead, the Indians made inclined ways up which they could walk with their panniers of ore, as the Mexican has done even in our own day. The maximum vertical depth was 40 feet. The ore was carried to the traders, who smelted it in the log-furnaces, the Indians being paid two dollars for 120 pounds of ore, but the payment was made

* Henry R. Schoolcraft, 'Expedition to the Sources of the Mississippi River', p. 173; 1855.

in goods at the trader's price, so that the ore probably cost him about 75 cents per hundredweight. The performance reminds one of the mythical dealings between the natives of Cornwall and the Phoenician ore-buyers in the far-off Cassiterides.

In 1802 Louisiana was retroceded to France, and in 1803 it was sold to the United States. In 1810 the Indians in the Galena district of Illinois were producing lead on a considerable scale, as John Shaw has told us. In 1811 George Jackson, a miner from Missouri, built a furnace on an island in the Mississippi near East Dubuque and took his lead to St. Louis in flatboats, although "he met with much opposition from the savages, who bitterly hated all Americans". A distinguished historian, Reuben G. Thwaites, says that "the volatile manners" of the French were more in accord with the character of the Indians, with whom they readily intermarried, and he acknowledges that the bearing of the Anglo-Saxon, meaning British and American, frontiersmen has ever been of a domineering kind, these stalwart pioneers being "the heralds of a relentless system of conquest". We must concede that the *coureurs des bois*, or rangers of the woods, from French Canada had better manners, certainly from the Indian warrior's point of view, for it was much more polite for the stranger to marry his daughter than to massacre his tribe, and the Frenchman by courteous dealings probably got more out of the aborigines than the relentless invader from the English-speaking regions.

Between 1815 and 1820, John Shaw made eight trips in his boat between St. Louis and Prairie du Chien, for the purpose of trading with the Indians. He visited the Fever River mines several times and saw the Indians smelting lead in rude furnaces. On one occasion he bought from them 70 tons of metal, "and still left much at the furnace".* In 1819 several American traders, who attempted to compete with the French Canadians in this region, were killed by the Indians. In the same year, however, there was a general

* *Wisconsin Historical Collections*, Vol. VIII, p. 250; 1890.

movement of Americans into these parts, for the purpose either of trading in lead or building small smelters, and many of the newcomers, we note, took Fox women for wives. This argues the beginning of better relations with the Indians. One of the chiefs, named The Buck, found a big mass of lead at this time in diggings about a mile above the site of Galena. The Indians expressed a desire to send the beautiful lump of galena to the Great Father at Washington, but as this was never done, we may infer that it was broken and then sold piecemeal to the traders at the current rate of a peck of ore for a peck of corn. The white men called the mine Buck's lead (or lode), and another near-by they named Doe's in honor of the chief's favorite squaw.

After the French trappers from Canada had started to exploit the lead resources of the Mississippi valley, and before the American miner gained control of the industry, there was an interval during which the Indians themselves mined, and even smelted, the lead ore, in imitation of their employers, men like Dubuque. In 1811 the Indian agent at Prairie du Chien reported that the Sauks and Foxes* on the east side of the river, lower down, and others on the western bank, had almost abandoned the chase except to procure the necessary meat, and were devoting their energies to the digging of lead. In 1810, he says, even with their crude methods of reduction, they had smelted 400,000 pounds of metal, which they had exchanged for manufactured goods, partly with venturesome Americans, but chiefly with Canadian traders, who took pains to incite opposition to their American competitors.† Of these, several took the risk and lost their lives during the decade 1810–1820. The Indians believed, and in this belief they were justified by subsequent events, that if the cupidity of the American adventurers was aroused by the richness of the lead deposits they would promptly

* Their true name was Miskaukis, but the French called them the Renards, meaning 'foxes'.

† Reuben G. Thwaites, 'Wisconsin', p. 200; 1908.

dispossess the Indians under cover of the treaty of 1804. By this treaty the Sauk and Fox claimants to the extensive lead-bearing tracts in Illinois, Wisconsin, and Missouri ceded this region to the United States, but, by a clause in the treaty, they were permitted to occupy their old camping-grounds until such time as the land was leased or sold by the Federal Government to real settlers.

Soon after the Louisiana territory passed into the possession of the United States, the Congress, by act of March 3, 1807, reserved all Government lands containing lead ores and authorized the leasing of them at a royalty of 10 per cent. Until 1822, however, the actual mining operations were desultory and unsystematic. In that year a Kentuckian, named Colonel James Johnson, obtained a lease in the Fever River district* now identified with Galena, in Illinois. The 'Colonel' had already been mining in these parts without a licence. He brought Negro slaves with him, together with some experienced miners, who were provided with the proper tools, so that, under cover of strong military protection, he was able to conduct his operations on a scale and in a style hitherto unknown in the lead country. Johnson's success soon attracted a horde of prospectors and squatters from Missouri, Tennessee, and Kentucky, as well as from adjacent parts of Illinois. These newcomers paid scant attention to the Government regulations. Those that had leases suffered from encroachment, and disputes were numerous. In August of 1826 there were 453 persons at work, and in 1827 the name of Galena was given to the principal settlement.

Soon prospectors were picking holes all over this Illinois-Wisconsin region, and the landscape became dotted not only with log shanties but also with the stockades that the prospectors erected to protect them against Indian assault, which was imminent. The Sauks and Foxes, together with some of the Winnebago Indians, in their crude way and for several generations, had been mining and smelting the lead ore in

* The French called it *Rivière au Fièvre.*

this region; they were now roughly pushed aside by the newcomers, whom they could not withstand unless they went to war. The shafts of the natives were boldly appropriated by armed white men, who evidently meant to stay, and such 'sink-holes' as the Indians had abandoned because they were too deep for their limited appliances were re-opened and worked by the intruders.

The land held by Dubuque when he died was relinquished to the United States by the Indians in 1832, and Dubuque's supposed heirs were forcibly ejected.* By the Act of 1807 all the Government lands containing lead were ordered to be reserved, and leases were authorized. No leases, however, were issued until 1822, and not much lead was produced until 1826, after which date the output increased rapidly, the rents being paid with tolerable regularity at first. Many of the farmers, with their Negro slaves, spent part of the year at the mines. They were slow to pay the royalty; it was reduced from 10 to 6 per cent; but even at that it was paid for a short time only. The Government found itself helpless in the matter,† because in 1835 the miners and smelters refused to make any payments. Whereupon, after much fuss and trouble, it was decided, in 1847, to sell the mineral lands.

Any prospector that found ore and took it for sale to the nearest smelter had to pay a fifth of his receipts to the owner of the land. If others came to the place of discovery, these later claim-holders had to pay four-fifths to the proprietor of the land. The discovery claim, however, when sold carried with it the original right to four-fifths of the produce. Hodge,‡ writing in 1842, describes some of the tricks of the trade:

"The proprietor may persuade miners to come and work in this way, or he may hire them on fixed terms, but the former

J. D. Whitney, 'The Metallic Wealth of the United States', p. 405; 1854.

† Isaac A. Hourwich, 'The Making of America', Vol. VI, p. 273; 1905.

‡ James T. Hodge, *American Journal of Science and Arts*, Vol. XLIII, p. 41; 1842.

is considered the preferable plan, because the miner is induced by it to raise as much ore as possible, and in the latter it is no object to him to take out any at all, and it is therefore frequently the case that when working on wages they will carefully conceal a rich lead, and work in unprofitable rock until the proprietor abandons the diggings, and years perhaps have passed, when they will come back and make a new discovery there, and work it on shares."

The agents of the smelters visited the mines and bargained for the ore on hand; when sold, the smelters sent their own wagons and teams to fetch the ore. The price paid fluctuated with the market price at St. Louis, with the competition between the buyers, and with the distance from the shipping-point, which was Galena, in Illinois. Lead was then worth three cents a pound at Galena. As the smelters paid cash for the mineral, and sometimes had to wait ten months before they received the proceeds from their shipments to an Eastern refinery, they were frequently in financial trouble.

The log-furnace, even when it was built upon a platform of masonry, was a crude affair and a wasteful method of smelting on account of the incompleteness of the chemical reactions. In 1834 Peter Lorimier erected a Scottish hearth on Catfish creek, in Iowa, and near Dubuque.* This furnace was still in operation in 1897. The adoption of the Scottish hearth, a type intermediate between a reverberatory and a blast furnace, was an important event in the history of the lead industry of the Mississippi valley. The only important change made in the modern practice with the Scottish hearth has been the use of electric power to rabble the charge, instead of the work done formerly by human labor. In the letters of John Marsh, who was stationed, as Indian agent, at Prairie du Chien in 1826, we get a good picture of the lead industry as conducted at that time in the face of opposition from the Indians. Prairie du Chien was on the Mississippi and 60 miles above the lead diggings of the Fever River district.

* A. G. Leonard, Iowa Geol. Survey, Vol. VI, p. 17; 1897.

where, in 1774, Dubuque had started mining by friendly arrangement with the Sauk and Fox tribes. Marsh wrote to his father in England as follows:

"The country abounds in lead ore—every hill is full of it. It is found in masses from the size of a bullet to a barrel, and even larger. It is truly surprising to witness the labour of these people. They [have] penetrated into the earth from twenty to eighty feet, and often through the solid rock. You may easily believe that men, stimulated by such prospects of gain, would not pay much regard to the rights of the Indians, who own the most valuable part of the mineral country. The agents of the Government have not been able to govern the miners, and nothing but a strong force can control them. A treaty will be held with the Indians next spring, to attempt to purchase the land. There is no doubt that the murders committed by the Indians last summer were partly caused by the aggressions of the whites. Eight of the Indians are now in irons at the fort [Fort Crawford, at Prairie du Chien], and will be tried and probably hanged next May. I expect that this and the treaty together will breed a war in which the Winnebagoes will be exterminated. This is now, has been, and I fear ever will be, the fate of the redman when he comes in contact with the white strangers."*

In the foregoing paragraph the whole story of the early settlement of the Mississippi valley is outlined: it was a contest between the white squatters and the red aborigines, to whom, of course, the land had belonged. The agents of the Federal Government were separated from Washington by a hard journey of five or six weeks, and the troops available in the district were always inadequate—a hundred men or so. The 'treaties' with the Indians were agreements forced down their throats with a rifle, and, as Marsh intimates, bred war, not peace. He says that common laborers were paid $20 per month, which, of course, was high pay in those days, and even at that they were hard to get, because anybody could

* George D. Lyman, 'John Marsh, Pioneer', p. 106; 1930.

seize a small piece of ground and dig ore for himself. There were plenty of traders that were willing to advance tools, provisions, and clothing on credit, to be paid in mineral when found. The ore, says Marsh, was current as silver coin at about $16 per 1000 pounds.

The Indians regarded the deposits of lead on their lands as part of their possessions. The swarms of white men, in their eager search for lead, disregarded the rights of the aborigines. Moreover, the American miners employed the Indians as workmen, and frequently the Indians that they employed belonged to a tribe that was the hereditary enemy of the particular Indians on whose lands they were trespassing; thus a double insult was offered. In 1826 there are said to have been 1500 Sauks at the mines in the Fever River district, where many of the discoveries of ore had been made on ground that was claimed by the Winnebagoes.

The prospectors and mining adventurers did not scruple to search for lead on territory that was outside the Government lands, they trespassed upon the hunting-grounds of the Indians, even where such grounds had been specifically reserved for the aborigines by treaty. That was one cause of the many Indian wars—chiefly ambuscades and massacres—during the American development of the Mississippi valley. The idea that the inhabitants—the Indians—had any rights to the country was treated as a joke when it stood in the way of profitable exploitation. The Black Hawk war, which looms large in the story of frontier days, was merely the dying protest of a brave savage when subjected to unendurable mistreatment.* In 1831 the squatters wrecked the village of Black Hawk, a Sauk chief; they ploughed the graves of his ancestors, scattered their bones, and desecrated their graves by planting crops. Is it strange that the Indian warrior retaliated, and in his own cruel fashion waged relentless war against the invaders? We make a heroine of Boadicea, who

* Henry C. Campbell, 'Wisconsin in Three Centuries', Vol. II. p. 189; 1906.

fought the Roman invaders of Britain, but we make only a bloody outlaw of Black Hawk, who resented the destruction of his hearth and home. Thwaites, the historian of Wisconsin and a keen student of frontier civilization, says that "the treatment of Black Hawk and his band, both before the war and during hostilities, is discreditable to us. It is a black chapter in the history of the West".* Undoubtedly the ill feeling between the savages and the settlers was extremely bitter, and no warfare more cruel, or more regardless of human decency, was ever waged. It was a war of extermination.

A good idea of the unruly condition of this American frontier in the first quarter of the nineteenth century is to be obtained from the performance of Henry Dodge in 1827–1828. With 50 men, well armed, he squatted on the lead-bearing land of the Winnebago Indians in the Wisconsin valley and started to produce the metal forthwith. Joseph Street, then living at Prairie du Chien, as Federal agent for Indian affairs, wrote to the office at Washington concerning Dodge as follows: "Many are flocking to him from Fever River, and he permits them to join upon paying certain stipulated portions of the original purchase. The ore is more abundant nearer the surface, and obtained with greater facility than ever known in this country. It is said that he has raised about half a million [pounds?] of mineral [galena?], smelted from 900 to 1000 bars, and is smelting 50 bars [each probably 70 pounds] a day. With two negro men in one place he raised about 2000 pounds [of ore] per day. What will be the effect of these high-handed measures I am at a loss to say". Soon this Federal agent had to face the dilemma; on January 26, 1828, a chief of the Winnebagoes came to the agency and complained that a large company of white men had gone far into his domain and was removing the lead ore. "The hills are covered", said the chief, "more are coming and pushing us off our lands to make the lead. We want our Father to stop this before blood may be shed." This reference is to

* Reuben G. Thwaites, 'Wisconsin', p. 207; 1908.

the President of the United States. The agent became alarmed, and sent his assistant, John Marsh, to the Dodge diggings, with orders to notify the farcical 'General' to move off the Indian lands instantly "if he did not wish to be removed by force".* But this was an empty threat. In the dead of winter Marsh had to go on snowshoes across the frozen wilderness, a distance of 95 miles to reach 'General' Dodge. He found that industrial pirate within a stockade; a meeting of the miners was called, and to them Marsh read the official message that he had brought with him. Then Dodge addressed the assembly, and insisted that there was no recognizable line of demarkation between the lands of the Winnebago Indians and those of other Indians, the Chippewas, Pottawattamies, and Ottawas of the Illinois, on which citizens of the United States had the right to dig for lead ore; and therefore that until such a line was definitely marked and established it was by no means certain that he and his associates were on the lands of the Winnebago tribe.

Marsh wrote, in a letter to Street, that he spent the rest of the day in looking around. "Ore is found", he said, "in great abundance near the surface, and in large masses. Few of the excavations are more than ten feet deep. The whole country appears to be literally full of lead ore, and the labor of obtaining it is trifling. Traces of old Indian diggings are found throughout the country for several miles. There are also furnaces where the Indians smelted the ore."† Dodge was living within a stockaded fort near the principal mine. There were twenty log houses in the immediate vicinity, besides several more at a distance. A double furnace was in constant operation, and a large quantity of lead in bars was on hand. The men engaged in these mining operations numbered 230, and they were fully armed with rifles and pistols.

Dodge's response to the official warning was to strengthen his fort and to provide himself with several hundred more

* Louis Pelzer, 'Henry Dodge', p. 33; 1911.

† George D. Lyman, 'John Marsh, Pioneer', p. 141; 1930.

rifles. Then he announced that if the officers and men of the regular army in those parts had more guns than he, they could come and try them. Street called upon the commandant at Fort Crawford, adjacent to Prairie du Chien, to remove the trespassers. The commandant replied that he had only 130 men fit for duty and that it was out of his power to comply with the request. Street could do nothing. Shortly thereafter, on August 25, 1828, the Winnebago Indians were expelled from their grounds and Dodge retained his mines unmolested. He waxed wealthy, shipping his lead from Helena on the Wisconsin river in his own steamers direct to New Orleans. After the treaty with the Indians was ratified, he became proprietor of more than a thousand acres, and upon his expansive domain during four decades he won fame and fortune, becoming three times Governor of the Territory of Wisconsin, Territorial Delegate to Congress, and eventually United States Senator, in which capacity, poetically speaking, he became in his old age an upholder of the law that in his early manhood he had defied.

At first, as we have seen, the lead was shipped down the Mississippi to New Orleans, for trans-shipment to Europe, but as early as 1822 some of the ore was carried to the Atlantic coast by way of the Fox and Wisconsin rivers to Lake Michigan; and this route was used for 20 years thereafter. In 1836 a company was formed to operate a combined wagon and boat service between Galena and Chicago, and from there by the Erie Canal to the eastern markets. In 1847 a Milwaukee paper speaks of the interest excited by the 'prairie schooners' that were constantly arriving from the lead districts, these picturesque wagons being drawn by six, eight, or more yoke of oxen.* The roads they followed became tempting avenues to the later agricultural settlers that went from the lake shore to the interior, and in this way the path of the lead miner became an important factor in facilitating the development of southern Wisconsin.

* Isaac A. Hourwich, 'The Making of America', Vol. VI, p. 273; 1905.

In 1845 the output of the Galena district was 54,495,000 pounds of lead, but the average price was under three cents per pound. Until 1850 iron and lead were the only industrial metals in the commerce of the United States; indeed, during the first 70 years of our national existence not one of our mineral resources served to supply adequately the needs of domestic manufacture.*

After 1845 the mining of lead in Missouri had begun to decline owing to the depletion of the surficial ore, but in 1867 the deeper exploration of the deposits in St. Francois county, which had been the scene of early mining operations, was successful in demonstrating that at a depth of a little over a hundred feet there was a limestone formation that contained lead in disseminated form. This new resource was exploited by the St. Joseph Lead Company, which eventually became the most productive lead enterprise in the world. This company was registered in New York on March 25, 1864, to acquire and exploit a tract of 946 acres, the property of Anthony La Grave, at Bonne Terre. The St. Joseph Lead Company started with a capital stock of $1,000,000, but this did not outweigh two mortgages, amounting together to $75,000, on the land it had acquired. Therefore the stock sold at half its par value, and, in default of working capital, the mining operations languished. Among other misfortunes may be mentioned a raid of Confederate troops under General Price. The report for 1865 showed $17,275 received from sales of lead as against an expenditure of $34,096.† Thereupon a new board of directors was elected; they went to the mines, made such examination as they could, and, what was more important, levied a voluntary assessment whereby the property was freed from debt. Another important step was taken: a number of Cornish miners were engaged, and a wood-

* Victor S. Clark, 'History of Manufacturers in the United States', Vol. I, p. 328; 1929.

† J. Wyman Jones, 'A History of the St. Joseph Lead Company', for private circulation, p. 8; 1892.

fired reverberatory furnace was erected. The operations became more fruitful. Abundance of ore was found in horizontal sheets, 6 to 8 inches thick, at a depth of only 4 to 8 feet. These flat masses of galena were blasted, and then broken with heavy hammers; next the ore was reduced further in a Blake crusher and Cornish rolls, after which the lead mineral was concentrated by the jigging process. The jig was a quaint contraption; it consisted of a heavy log, or 'horse', across which was laid a long pole, having at one end a man astride and at the other a suspended sieve filled with crushed ore to which water was supplied. The persevering up-and-down motion of the man at one end of the pole served to give a similar agitation to the material in the sieve at the other end, so that the heavy particles of galena sank to the bottom and the light particles of gangue rose to the top, to be removed by hand. The concentrate collected at the bottom of the sieve was carried to the furnaces. These were stone ovens with a sloping bottom, reminiscent of the older log-hearths; at one side was a fire-box for wood fuel; and at the front, or lower end, was an opening through which the molten lead ran into an iron pot, from which it was ladled into moulds. Such a furnace when operated by six men would produce 32 pigs, each of 72 pounds, in 24 hours. The operations were too laborious to leave any comfortable margin of profit; the ore did not average more than 6 per cent of lead, and a day's work at the furnace did not yield more than 2300 pounds of metal worth 5 cents per pound. The mine workings were shallow; in wet weather they were filled with water; in winter, the sleet and ice handicapped the miners; in dry weather, the supply of water was insufficient for the mill; therefore the season of active work did not exceed six months and only 6000 pigs of lead, or 216 tons, could be produced in the course of a year. The ore, however, was abundant, and that was a factor of prime encouragement. As the diggings were extended underground and shallow drifts were extended they ran into richer ore and at the same

time gave the miners better protection from the weather, besides developing a supply of water, which, by aid of pumps and a reservoir, enabled the ore-dressing to proceed less interruptedly. To facilitate the smelting, the sulphur content of the ore was decreased by calcining it previous to reduction. The mill also was improved in sundry details.

The decisive factor in bringing success to the St. Joseph Lead Company at this stage in its history was not a machine, but a man: Charles B. Parsons. He was occupied in the dressing of lead ore at Northampton, in Massachussetts, when he was invited to become superintendent of the mill at Bonne Terre, to which place he came in 1867. The president of the company, J. Wyman Jones, and later writers also, testify enthusiastically to the value of his services in putting the St. Joseph Lead Company on its feet. "He won the esteem and confidence of the entire community", we are told. Later he became resident director, in which capacity he continued until his death in 1910—a span of 43 years of exemplary professional service at Bonne Terre. To aid Parsons in making necessary improvements, a bond issue of $100,000 was authorized, 30 cents being payable in cash and 70 cents in shares of the company at par. These bonds proved burdensome to the company, but they were redeemed at intervals and were finally liquidated in 1881, by which time $175,000 had been paid in principal and interest. Troublesome they may have been, but they gave the financial aid needed at a critical period.

In 1869 a diamond-drill, the only one in the United States, was brought to Bonne Terre. The drill had been imported from France and was not an efficient machine, but it was operated by a capable man, Albert Shepard, and it yielded important information concerning the distribution of the ore at depths not yet reached in actual mining. The ore-bearing formation is a dolomitic limestone, about 500 feet thick and lying horizontal, in which the lead ore is found in layers and masses of irregular shape and extent at varying depths, but

in greatest quantity within the lower strata. The borings made by Shepard cut into mineral at 120 feet, thereby disclosing a new ore-bearing horizon. Thereupon a shaft was sunk, which in those days meant the work of six months. The shaft found no ore, as not infrequently happens in the wake of a bore-hole. However, a drift soon penetrated into ore, which proved to be the fringe of a large area of productive ground. The diamond-drill was most useful in prospecting, and enabled the company to find ore-measures of wide extent, the yield in later years being about 75 pounds of lead per ton of ore. This lead, it may be noted, is free from other metals, the traces of silver, copper, and other impurities being so slight as not to require removal from the pigs as marketed. In course of time large chamberlike excavations were made underground, these being sustained by pillars of rock, in places rich in lead but too useful as supports to be removed. The ore-bearing stratum was found to be as much as 60 feet thick over an area of many acres. Through the workings the broken ore was drawn in cars pulled by mules, until electric power was substituted. In 1874 the first dividend was paid.

In early years the company's operations suffered from lack of railroad connection; the supplies and machinery coming inward, like the shipments of lead going outward, had to be hauled over a rough wagon-road to Summit, a station 14 miles from Bonne Terre on the Iron Mountain railway. In the spring and fall, the teams of four or six mules dragged the wagons, loaded with twenty or thirty pigs of lead, through the tough mud, slowly and painfully, so that at times the haulage cost more than the lead ore was worth. In 1880 a narrow-gauge track was completed to Summit under the joint ownership of the company and its neighbor, the Desloge Lead Company. This railroad was used not only for shipments of metals and supplies, but also to remove the tailing, or 'chats', from the mill. Previously, owing to the flatness of the local terrain, this had to be done by ox and mule wagons.

In 1882 the company produced 15,214 pigs of lead. Early in the following year, however, the mill was destroyed by fire, and the disaster seemed overwhelming; but the old mill consisted of a group of straggling wooden buildings, the increment of years, so badly arranged that economical work was impracticable; therefore it was not difficult to turn the disaster to advantage by designing and building a much better mill, as Parsons proceeded to do forthwith. This plant had a capacity of 500 tons and was patterned after the practice in vogue at Joplin, but it was equipped with his own, instead of the Cooley, jig. A side-bump Rittinger table was another interesting feature.* This mill was in use for 15 years, its capacity being increased finally to 800 tons per day. In 1887 the ore yielded 5·65 per cent of lead; the tailing contained 2·13 per cent, or 27·4 per cent, of the mill-feed, this high loss being due mainly to the sliming of the galena. The cost of milling at that time was 36·4 cents per ton. After the death of Parsons, many changes were made in the mill, his jig being replaced by the Hancock, and the Rittinger tables by Wilfley's. In 1916 the capacity of the mill had been increased to 2400 tons daily.

The company increased its mining resources by purchasing a tract of 344 acres known as the Penn Diggings in 1883; and three years later the Desloge Lead Company, owning 3218 acres, was absorbed. Here it must be explained that Firmin Desloge re-entered the lead-mining business and started the Desloge Consolidated Lead Company in 1894,† this enterprise in turn being absorbed by the St. Joseph Lead Company in 1929. In 1890 a railroad to the Mississippi was completed, and thereby permitted the erection of a smelter at Herculaneum, a mile south of the Riverside station, which is 32 miles from Bonne Terre.

* A. P. Watt, *Trans.* Amer. Inst. Min. and Met. Eng., Vol. LVII, p. 330; 1917.

† H. A. Guess, *Trans.* Amer. Inst. Min. and Met. Eng., Vol. XLVIII, p. 33; 1914.

By aid of the new railroad and of the smelter, the operations of the company developed in extent and productivity. The period of most rapid growth has been during the past 16 years. The multiplicity of shafts and of haulage to the mills has been corrected by a system based upon the use of four shafts alongside as many mills, all the haulage underground being done by high-speed electric locomotives running over an extensive series of tracks. Until 1920 the ore when mined was shoveled by hand; today most of the output is loaded by electric shovels, each of which does the work of a dozen men. Electric power is generated at a central station, where pulverized coal is burned under boilers in much the same manner as gas or oil, the output being 12,500-kilowatt turbine units. The coal comes from southern Illinois. The use of the flotation process in the mills has decreased the loss in slime, the minute particles of galena being saved, so that for every 100 pounds of lead in the ore mined, over 90 pounds of lead is recovered in the concentrate that is shipped to the smelter.

During its life so far of 66 years the St. Joseph Lead Company has had only three presidents: J. Wyman Jones, from the start to 1904; his son, Dwight A. Jones, from 1904 to 1913; and Clinton H. Crane, from 1914 to the present time. During the World War the lead output of this company's mines proved of immediate and great value. On the very day that the United States declared war, namely, April 6, 1917, Mr. Crane became chairman of the Committee on Lead of the Advisory Committee of the Council of National Defence. The committee undertook to furnish, and did furnish, the lead required by the Government at a price less than that of the current market, which market price fluctuated violently in common with that of most commodities in those hectic days. Subsequently, in 1918, when the tremendous demand for munitions created an acute condition in the lead market, the administration of the entire American and Mexican lead output was undertaken by the Lead Producers' Committee

for War Service, with Mr. Crane as chairman. It is estimated that near the end of the war less than 10 per cent of the country's production of lead went into uses other than those vital to the victory of the Allies. The St. Joseph Lead Company from the date of its organization to December 31, 1929, produced 2,707,957 tons of lead, the sale of which has permitted the distribution of $63,963,189 in dividends. The lead of the Mississippi valley has proved of critical importance both in peace and in war.

The first discovery of lead in the American colonies was made fourteen years after the landing of the first English settlers in Virginia.* In 1621 lead deposits were found on Falling creek, near Jamestown. The demand for bullets created a market for the metal, and the giving of guns to the Indians for shooting fur-bearing animals caused the lead to be highly appreciated by the natives of the interior. In 1765 a lead mine was worked at Southampton in Massachusetts by a Connecticut company; it was abandoned during the Revolution and re-opened in 1809; but it proved unprofitable, and work was stopped finally in 1828. In Maine, Connecticut, and Pennsylvania lead has been found and mined on a small scale at various times. Lead is needed in warfare, as the American revolutionists discovered. A leaden equestrian statue erected in honor of George III in 1770 had to be sacrificed to their needs; it was used to make bullets for the purpose of destroying His Majesty's soldiers. We are told that the statue was melted by Governor Winthrop of Connecticut, and that it was converted into 42,000 bullets. In 1777 the Congress of the United States recommended that the lead mines in the State of New York be exploited, and promised to supply prisoners of war for the purpose in the event of an inadequate supply of ordinary labor.† The only lead mine of any consequence in New York State was the Livingston,

* W. R. Ingalls, 'Chronology of Lead-mining in the United States', *Trans.* Amer. Inst. Min. and Met. Eng., Vol. XXXVIII, p. 664; 1907.

† *Journal of Congress*, Vol. III, p. 462.

at Ancram; this mine was worked later during the Civil War, but the yield of lead proved insufficient. The principal lead mines at the time of the Civil War were in the possession of the Southern Confederacy; in consequence, the Union troops had to make bullets by melting the lead gutters of the roofs and the pewter pots of the pantry.

The production of lead in the frontier settlements of the Upper Mississippi was a factor in the industrial development of American territory. The lead obtained at first, on a small scale and in a crude way, was used not only by the fur-traders but by the Indians from whom they bought the pelts. This trade did little to develop the resources of the region, because the fur-buyer was secretive; he wished to be let alone in his preserves; he welcomed no newcomers. The news of lead being found served to attract the miner, who soon changed the petty dealings into an important business; he was not secretive; as soon as he had staked his claim, he invited others to come; he laid the foundations of a permanent and profitable industry; he was the true pioneer of civilization in the Mississippi valley, as he had been, or was destined to be, in many other backward parts of the earth.

CHAPTER VIII

THE GREAT SALT LAKE

In 1776 two Franciscan friars, Domínguez and Escalante, started to find a direct route from Santa Fé to Monterey, and in their misguided wanderings northward they reached Timpanogos, now known as Utah lake, where they heard of a much larger body of water to the northwest, of which they were told that it was extremely salt.* They never saw this great lake, because they passed south of it on their way to the Pacific coast.

The Dead Sea of North America was discovered in 1825 by James Bridger, a trapper. He and other trappers had ascended the Missouri and had reached the Bear river. A discussion arose as to the course of this river, and a bet was made, to settle which Bridger followed the Bear river to its source, in the Uintah mountains, and from the crest of the watershed he caught sight of the lake, to which he then descended.† He tasted the briny water of the inland sea and wondered if it were an arm of the Pacific Ocean.

The lake was first seen by the Mormons on July 24, 1847. A band of them, numbering 145 and led by Brigham Young, had migrated from Missouri in search of a new home in the western wilderness. It is recorded that when Brigham Young stood on the summit of the pass over the Wasatch range and saw the valley of the Jordan outspread before him, he exclaimed: "It is enough. This is the right place". He had seen it in a vision, so he claimed, and foresaw the future glory of the new Zion that was to be planted in that happy

* *Diario Documentos Históricos Mexicanos*, Series 2, Vol. I, p. 454; 1854.

† H. H. Bancroft, 'The History of Utah', p. 20; 1889.

valley. The proper name of the Mormons is the Church of Jesus Christ of Latter-day Saints, a name adopted by them in 1834 while they were settled in Missouri. This sect had been founded by Joseph Smith, at Manchester, New York, in 1830, in consequence of a vision in which the Book of Mormon, in golden tablets, was revealed to him by the angel Moroni, the son of Mormon, both of these persons, it is alleged, having survived a fierce war between groups of Hebrew settlers that came to America from Jerusalem by way of Chile. At one time the word Mormon was supposed to represent the English transliteration of the Greek word *mormōn*, but Joseph Smith denied this derivation* and said that 'Mormon' came from the Egyptian *mo*, meaning 'good', and the English word 'more', abbreviated to 'mor', so that it meant literally 'more good'. This sounds like the "delirious trimmings" of philology. The nearest Greek word is *mormōn*, meaning a 'bugbear' or 'monster'. The Egyptian for 'good' is *menkh* and *mensh*.

Joseph Smith was born in Vermont in 1805; he was working at a silver mine at Harmony, Pennsylvania, in 1825. When persecuted, on account of his alleged visions, he fled from Vermont to Pennsylvania, where he began to write the Book of Mormon. He gathered followers and led them to Ohio, Missouri, and Illinois, successively, as they were driven by persecution from one State to another. Smith was murdered at Carthage, Illinois, in 1844. Whereupon the sect he had founded decided to go to the far West, under the leadership of Brigham Young, who had succeeded Joseph Smith as the Prophet of the Latter-day Saints. Young, who was also a Vermonter, was then forty-three years of age; he was an able and energetic man.

The Mormons thought to escape the jurisdiction of the United States government by their migration to the Salt Lake region, which at that time was not within the national domain, but they were thwarted by the treaty of Guadalupe Hidalgo,

* William Alexander Linn, 'The Story of the Mormons', p. 108; 1902.

signed on February 2, 1848, at the close of the Mexican war. By this treaty Mexico ceded an immense stretch of western territory to the United States, including the region over which Brigham Young and his followers had established control. Early in 1849 the Mormon community was organized as the State of Deseret, with Young as Governor. According to the 'Book of Mormon' the word 'Deseret' means 'land of the working bee', a fitting symbol for this industrious people and one that is perpetuated by the beehive that now appears on the seal of the State of Utah. Deseret comprised not only the Utah of today but also Arizona, Nevada, and parts of New Mexico, Colorado, Wyoming, and California. Brigham Young claimed a sway imperial in its perspective. In 1850 Deseret was admitted into the United States as the Territory of Utah; it had shrunk in area, but still included portions of New Mexico, Colorado, and Wyoming. On January 4, 1896, the State of Utah was organized and admitted into the Union. Utah is a corruption of Ute, the name of an Indian tribe.

The Mormons had a goodly heritage. In 1860 Sir Richard Burton, the famous traveler, stood at Emigrant Gap and thus described the view in his diary:*

"The sun, whose slanting rays shone full in our eyes, was setting in a flood of heavenly light behind the bold, jagged outline of 'Antelope Island,' which, though distant twenty miles to the northwest, hardly appeared to be ten. At its feet, and then bounding the far horizon, lay, like a band of burnished silver, the Great Salt Lake, that still innocent Dead Sea. Southwestward also, and equally deceptive as regards distance, rose the boundary of the valley plain, the Oquirrh Range, sharply silhouetted by a sweep of sunshine over its summits against the depths of an evening sky, in that direction so pure, so clear, that vision, one might fancy, could penetrate behind the curtain into regions beyond the confines of man's ken. In the brilliant reflected light, which softened

* Richard F. Burton, 'The City of the Saints and across the Rocky Mountains to California', p. 194; 1862.

off into a glow of delicate pink, we could distinguish the lines of Brigham's, Coon's, and other kanyons, which water has traced through the wooded flanks of the Oquirrh down to the shadows already purpling the misty benches at their base."

Since then many shadows have crossed the range. "Our lives are like the shadows on sunny hills that lie." But the sunsets retain the same quality of beauty and the clear ether still provokes the imagination of man. Sir Richard spells 'canyon' in his own way, and was led by deceptive analogy to speak of Brigham, instead of Bingham, canyon. Bingham has proved industrially as important as Brigham was politically. The English traveler was so exhilarated by the fresh mountain air that to him it seemed "Switzerland and Italy lay side by side". To him the Salt Lake valley, "this lovely panorama of green, and azure, and gold—this land, fresh, as it were, from the hands of God", was worthy to be the Zion of the Latter-day Saints, and also of later sinners.

The discovery of the mineral deposits of Utah was retarded by the opposition of the Mormons, who intended to make agriculture the basis of their industrial development. They discouraged, and tried to frustrate, the search for minerals. "This opposition", as Emmons* said, "and the natural obstacles in the way of cheap mining or of an economic reduction of the generally rather refractory ores, acted as an effectual bar to the development or even the discovery of the mineral resources of the Territory in its early days." The transcontinental migration that ensued after the discovery of gold in California did not lead to any important find of ore in this region, because the leaders of the Mormon church were successful in preventing it, "fearing that the exciting and unsettling influence of that pursuit [mining] would turn away their people from the more monotonous and peaceful occupations of agriculture, and thereby interfere with their great work of reclaiming the desert, and fearing, also, that the

* S. F. Emmons, U. S. Geol. Survey, *Sixteenth Annual Report,* part 2, p. 352; 1895.

restless and sometimes rather lawless class of people who are attracted by mining excitements might prove a disturbing element in the population and tend to subvert their almost autocratic authority".*

When the brethren slid their logs down the mountain-side they disturbed an occasional piece of lead ore and dreamed of mineral wealth that might contribute to the embellishment of the Temple and the glorification of Zion, but their Prophet warned them to stick to the building of homes and the development of farms until such time as the Lord saw fit to "reveal to them the hidden treasures of His storehouse".† Orson F. Whitney, a Mormon bishop, in his history of Utah, exclaims: "Who wished to see Deseret, peaceful Deseret, the home of a people who had fled for religious freedom and quiet to these mountain solitudes, converted into a rollicking, roaring, mining camp? Not the Latter-day Saints".

The logic of events proved too strong for the Mormons in Utah as it proved too strong likewise for the Boers in the Transvaal. Indeed, the analogy is not sufficiently appreciated. The Boers left the Cape Colony in order to escape from British control; they believed in the practice of slavery, and quoted Biblical authority in support; they also wanted ample room for their pastoral industry. So they crossed the Vaal and started new settlements beyond the reach of European interference. The Mormons, desiring to escape from the legal control of established American communities, believing in the practice of polygamy, for which likewise they quoted the Biblical text, and hoping to develop a purely agricultural industry in an isolated region, migrated into the western wilderness and settled on the shores of the Great Salt Lake. Nor must it be forgotten that the Mormon people were largely British. Boer and Mormon alike expected to remain detached from the civilization they had abandoned, each intended to pursue his own mode of living in the outer wilderness, each

* *Ibid*, p. 351.

† T. B. H. Stenhouse, 'The Rocky Mountain Saints', p. 712; 1873.

was disappointed and thwarted by the oncoming tide of industrial progress. The pioneers of mining in their eager search for mineral wealth, invaded the Transvaal and Utah, at first peaceably and then aggressively, gaining a foothold as their numbers increased, attracting others for the same purpose in ever increasing numbers, until the original settlers were overwhelmed and over-ridden. Slavery was as repugnant to the Briton as polygamy was repugnant to the American. The perpetuation of these practices created a prejudice against the Boers and the Mormons respectively, and under cover of that prejudice the miner was enabled to obtain military protection, the effect of which finally was to submerge the political islands that the Boer and the Mormon alike had tried to create in the midst of a continent.

So Brigham Young failed to realize his purpose of establishing a separate people, but he succeeded, even beyond his dreams, in laying the foundations of a thriving community on the shore of the great lake. Any disparagement of the Mormons on account of their opposition to mining or on the score of their polygamous habit must be joined with a hearty admiration for their energy as pioneers and with high praise for their thrifty enterprise. To this day they set a good example to the people of the West by their intensive farming, collective loyalty, and intelligent co-operation.

The existence of silver ore near the lake became known in 1857, but Mormon influence prevented the development of mines. In 1862, during the Civil War, the Third California Infantry happened to be stationed at Camp Douglas, overlooking Salt Lake City. Many of the soldiers in this volunteer regiment had seen something of gold-mining in California; their commander was General Patrick E. Connor, who, it is said, looked to immigration as the best means of settling the Mormon question, then becoming troublesome. He encouraged prospecting therefore, and granted furlough to his men so that they might have frequent opportunity for exploring the neighboring mountains, when not engaged in preventing

depredations by the Indians (Piutes and Goshutes) and not otherwise occupied in keeping an eye on the Mormons, who were unfriendly. Bancroft* says: "The first systematic efforts at prospecting, made by permission of General Connor, when in command at Camp Douglas, were ridiculed in the tabernacle; and later, when mining projects were brought forward by Gentiles [those who were not members of the Mormon church], they were steadily discountenanced". Whitney,† writing from the Mormon standpoint, says of Connor: "His object was to reconstruct Utah, to put the Mormons under and render the Gentiles paramount. To effect that object he strained every effort of his energetic soul; hesitating not to exaggerate grossly, not only the growth of the infant industry of mining, making it appear a very giant at its birth, when everyone knows that for years it was a mere babe in arms, never attaining to any proportions until after the advent of the railway, but also the general condition of affairs at Salt Lake City and throughout the Territory".

At that time Bingham canyon was valued by the Mormons for its fine timber, red pine three feet in diameter being plentiful there. Early in the autumn of 1863 an apostate Mormon named George Ogilvie found fragments of lead ore in the canyon and took them to Camp Douglas, where they were exhibited to General Connor. On September 17, 1863, the discovery was located as the West Jordan, which was the first mining location made in Utah. In the following December a mining district, the first in the Territory, was organized under the name of West Mountain, which is the English meaning of the Indian word Oquirrh. It included the northern portion of the Oquirrh range. Bancroft‡ recounts the episode: "In 1863 Captain A. Heitz and a party from Camp Douglas discovered argentiferous galena and copper in Bingham canyon, on the east slope of the Oquirrh range, near the Jordan, and

* H. H. Bancroft, 'History of Utah', p. 741; 1889.

† Orson F. Whitney, 'History of Utah', Vol. II, p. 111; 1893.

‡ Bancroft, *op. cit.*, p. 741.

about thirty miles south of Salt Lake City. A mine was located in September of that year by a man named Ogilbie, and in December following a mining district was established, named the West Mountain, and including the portion of the range between Black Rock, at the southern end of the Great Salt Lake, and the fortieth parallel. In 1871 this district contained 35 mines".

Whitney's description* may be compared with the foregoing: "A party of soldiers from Camp Douglas were guarding some horses belonging to the garrison which [the horses, not the garrison!] had been sent to graze in Bingham Canyon. They were joined one day by General Connor and a picnic party of officers and their wives from Camp [Douglas], and one of the ladies, while rambling on the mountain sides, picked up a loose piece of ore. The soldiers at once prospected for the vein, discovered it, and striking a stake in the ground made their location, since which Utah has been known to the world as a rich mining country". Another account, by the historian Tullidge, states that a man named Ogilvie, while logging in the canyon, found a piece of ore, which he sent to General Connor, who had it assayed. It was then, according to Tullidge, that Connor organized his picnic party and proceeded to Bingham canyon for the purpose of locating a claim, which was named the Jordan. Soon afterward Connor wrote some mining laws and held a miners' meeting at Gardner's mill on the Jordan river, where the laws were adopted and Bishop Gardner elected recorder of the West Mountain mining district.† Thus was the ball set rolling.

The discrepancies between these various accounts of the discovery are typical of most stories dealing with such events. Unless the facts are set down in writing at the time, they are readily twisted or obscured by the desire to give credit to one or other of the participants in the affair.

* Whitney, *op. cit.*, Vol. II, p. 107.

† Edward W. Tullidge, 'History of Salt Lake City', p. 698; 1886.

Connor and his associates started a newspaper for the purpose of making known the mineral resources of the Territory; it was named the 'Union Vidette', and its first issue, of November 20, 1863, contained this announcement:

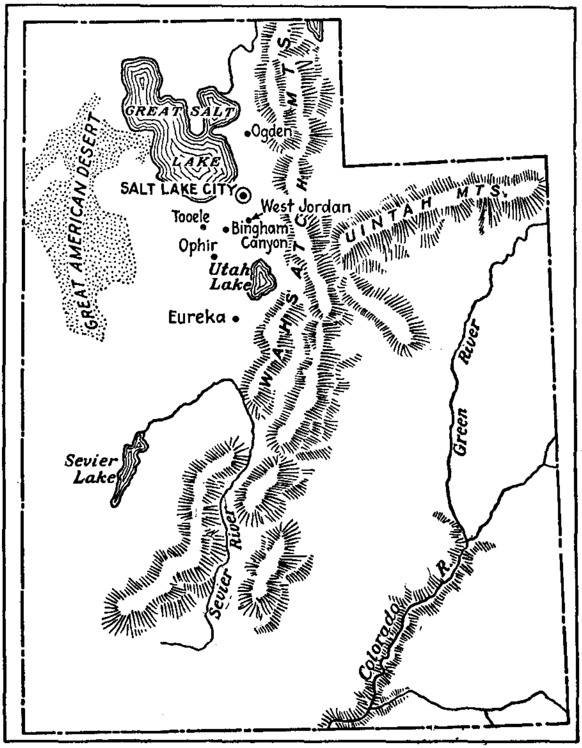


FIG. 15.—The Salt Lake region. (*Reproduction licensed—base material copyrighted by Rand McNally & Company.*)

"The general commanding the district has the strongest evidence that the mountains and the canyons of the Territory of Utah abound in rich veins of gold, silver, copper, and other minerals; and for the purpose of opening up the country to a new, hardy, and industrious population, [he] deems it important that prospecting for minerals should not only be untram-

melled and unrestricted, but fostered by every means. In order that such discoveries may be early and reliably made, the general announces that miners and prospecting parties will receive the fullest protection from the military forces in this district, in the pursuit of their avocations; provided always, that private rights are not infringed upon."

Such was his challenge to the Mormon hierarchy.

In the summer of 1864 the West Jordan Mining Company was incorporated under the laws of California, and a tunnel was started, at $60 per foot. In the same year the first smelting-furnace was constructed by General Connor, who had enlisted the help of friends in California; but they were inexperienced, save in placer mining, and failed completely in this venture. In June, 1864, another mining district, named the Rush Valley, was organized. This covered the western slope of the Oquirrh range, leaving the eastern side to the West Mountain district. Vigorous prospecting ensued; but these early operations languished, in spite of the discovery of several handsome outcrops of argentiferous lead mineral, because so many obstacles stood in the way of profitable mining. The lack of railroad transport rendered all supplies exceedingly expensive; a shovel cost $2·50, a keg of powder, $100. Moreover, the influence of the Mormon church was effective in discouraging the settlers in the Salt Lake valley from participating in the development of these lead resources. Alluvial gold is the best mineral for pioneer mining because it is extracted by simple methods, and, on account of small bulk in proportion to high value, is cheaply transported. The first discovery of gold, therefore, is an important event in the history of any region. A party of Californians when returning from Montana to spend the winter in the Salt Lake valley, in 1864, found gold in Bingham canyon, and began forthwith the systematic washing of the gravel along the stream. A nugget weighing a little more than an ounce was found at the start, and these alluvial operations are said altogether to have yielded a million dollars during the ensuing six or seven years.

The first mining at Bingham was prompted, as we have seen, by the silver-bearing lead ore that outcropped on the hillside and by the gold that was found in the gravel of the gulch. Later, gold was won from quartzose veins that traversed the limestone. In 1882 four stamp-mills had been built to treat this gold-bearing ore. The success of the lead-mining, which was contemporaneous, was due not only to the silver contents of the ore in such mines as the Jordan, Galena, and Winnemucca, but also to the intense oxidation of the mineral, which yielded easily reducible carbonate ore even at a considerable depth in such mines as the Brooklyn, Lead, and Yosemite.

The completion of railroad communication led to the mining of silver ore in Little Cottonwood canyon, in the Wasatch mountains, in 1864, by some of General Connor's men, but it was of no consequence until four years later. The Emma mine was located in this district by Woodman in 1868, and subsequently, when sold in London, gained ill fame in consequence of a fiasco. At first the mine was highly productive, yielding daily a hundred tons of ore containing 200 to 700 ounces of silver per ton. General Schenck, U. S. Minister to England, was prominent in forming a $5,000,000 company in London for the acquisition of the Emma. In a few months $1,500,000 was taken out of the mine, and then the orebody petered out suddenly. General Schenck was ruined and had to flee from London to escape prosecution.* During the excitement caused by these events, a discovery of hornsilver was made in a canyon, now known as Ophir, on the west slope of the Oquirrh mountains, where the first location was made on August 23, 1870. On this claim, named the Silveropolis, so-called boulders of the silver chloride were found at grassroots. The Walker brothers shipped 40 tons that netted $24,000 from the surface workings of the Silveropolis. The news of such rich finds served to attract miners from the other parts of the West to Utah.

* P. Donan, 'Utah', p. 36; 1895.

The first shipment of ore from Utah, according to Bancroft,* was "a carload of copper ore from Bingham canyon, hauled to Uintah on the Union Pacific, and forwarded by the Walker Brothers to Baltimore in June 1868". This happened before the transcontinental railroad was completed by the linking of the Union Pacific and Central Pacific lines at Ogden on May 10, 1869, and it was two years before Salt Lake City was joined to the main line by the construction of the Utah Central railroad. The mention of copper so early is interesting, because no large shipments of such ore were made until December, 1896, when 5000 tons of sulphide ore was shipped from the Highland Boy mine, at Bingham. It is worthy of note that the original Highland Boy company was started as a gold-mining venture by Samuel Newhouse, the promoter, and Thomas Weir, the manager. These two had so little idea of developing a copper mine that they built a cyanidation mill to extract the gold in the oxidized ore. This mill ran for several months, but it was not a success, chiefly because the copper, which they had ignored in their experimental work, interfered with the recovery and caused an excessive consumption of cyanide. After the mill proved a failure and the company's affairs had reached a critical stage, Newhouse, it is said, went to Denver in order to raise money to meet his delinquent pay-rolls, and while there he received a telegram from Weir informing him that ore containing 15 per cent of copper had been struck in the lower adit. This saved the day. Another story asserts that in the course of exploratory work in the zone of oxidation a winze penetrated sulphide ore. This so alarmed the management that the winze was covered. Later, failing to develop a successful gold mine and the price of copper making that metal attractive, the winze was re-opened and a discovery of copper sulphide was announced.

At first, as has been explained, the copper deposits were overlooked. They were of low grade and not as easily smelted

* H. H. Bancroft, 'History of Utah', p. 741; 1889.

as the lead ores. The shipment of copper-sulphide ore from the Highland Boy in 1896 gave the promise of a new departure and led to the transfer of this mine, together with other claims, to the Utah Consolidated Mining Company, which, three years later, completed the building of a smelter of 250 tons' capacity. In 1897 the Stewart No. 2 and a number of adjacent claims were acquired by the Boston Consolidated Mining Company. As yet, however, there was no mention of the mine that was to give fame to Bingham and to Utah.

It is probable that the first mining on the present Utah Copper property was done at the time when General Connor's soldiers began to prospect in the hills enclosing Bingham canyon, that is, soon after 1862, for the Soldier tunnel, by its name, perpetuates that tradition. The oldest claim now included in the property is the Washington, which was located in 1865, whereas the latest claim, the Jubilee Fraction, was located on November 29, 1910, seven years after the Utah Copper Company was organized.

The story of this famous enterprise* begins with Colonel Enos A. Wall, of Indiana. As he himself acknowledged smilingly, his military title was one that he owed to his friends. Such were the amenities of frontier days. His parents were North Carolinian; he started his mining career in Colorado in 1860, and went from there to Montana in 1863, varying the search for gold with general business as a freighter and trader in the material and supplies exchanged between that Territory and Utah, to which he came in 1868, remaining there for fourteen years. Then for five years he was chief stockholder and superintendent of the Wood River Gold & Silver Mining Company, at Bullion, Idaho, where he won the regard of his fellow-citizens so as to be elected to the upper house of the Territorial legislature and president of that chamber. In 1885 he returned to Utah, engaging in mining at Mercur and elsewhere.

* T. A. Rickard, 'The Utah Copper Enterprise'; 1918. Also *Mining and Scientific Press*, Vol. CXVII, p. 445; 1918.

In July, 1887, Wall went to Bingham, where his attention was attracted to a discoloration on the hillside, visible from the road. The water issuing from a spring just above the site of the 'pit' of the Utah Copper mine, as it was in 1918, had been conducted to a placer near the site of the present railway station. The bare rock on the hillside had become discolored and the gravel in the gulch likewise was stained green by the coppery solution. When examined, the ridge of rock proved to be an outcrop of monzonite impregnated with copper sufficiently to assay 3 per cent for a length of 300 feet. An abandoned tunnel, 90 feet long, had been driven into the hill on the line of a short fracture that had yielded pieces of ore rich in chalcocite. Entering this tunnel, Wall broke a sample; upon the fresh face of rock, underneath the green stain, he saw that the monzonite was spotted with chalcocite and bornite, suggesting to him a similarity to the ores of Butte, with which he was familiar. He sampled the tunnel and obtained an average of 2·4 per cent of copper by assay. Numerous tests by panning showed that a concentrate assaying 30 to 40 per cent of copper could be produced. That was the discovery of the Utah Copper mine.

Upon enquiry at the Recorder's office, Wall ascertained that the ground covering the area in which he was interested had been abandoned, and therefore was open to re-location; so he staked the Dick Mackintosh and Charles Read claims, naming them after two of his friends. He located other claims and found other abandoned workings, in which he saw more evidence of an extensive dispersion of copper in rock that had been too poor for selective mining. At that time he lacked the money needed for systematic development, but he did his assessment work faithfully from year to year. Later he made some money by sundry deals at Ophir and Mercur. He was not a promoter, but a miner and a dealer in mines, backing his personal judgment successfully and establishing a good bank-credit in Montana and Utah. Meanwhile he retained his faith in the copper-bearing porphyry at Bingham, and looked

forward to acquiring the financial resources required to provide the equipment for exploiting the deposit on the large scale that it demanded. By the time the Highland Boy started a local copper excitement, in 1896, he had secured 200 acres and had done $20,000 worth of exploratory work, as represented by 3250 feet of workings.

Enter Captain Joseph R. De Lamar. He was born in Amsterdam; he had been a diver; he had commanded cargo-ships between New York and Bermuda; his captaincy was of the sea. His mining adventures had extended all the way from the Sangre de Cristo mountains to Lake Nipissing. De Lamar had known Colonel Wall at Mercur, for, among other dealings, he had bought from him the Brickyard mine in 1894. At that time the Captain's chief of staff, or manager, was Hartwig A. Cohen. In 1895 Cohen examined Wall's copper prospects at Bingham, and expressed a favorable opinion; whereupon De Lamar took a six-months' option on three-quarters of the property at $375,000. A test was made on 76 tons of ore in a small stamp-mill, the result being a recovery of 60 to 62 per cent in a concentrate containing 28 to 33 per cent of copper from a 2 per cent ore. No business ensued, however. De Lamar thought the recovery discouraging and the outlook for copper unpromising, the price of the metal having fallen at that time to 9¾ cents per pound as against 12 cents a year before.

Three years later, De Lamar obtained another option, this time on a quarter interest at $50,000, and on a second quarter at $250,000. The workings were sampled by Robert C. Gemmell and a test of the ore was made by Daniel C. Jackling, both of these engineers being on the Captain's staff. The subsequent negotiations, however, broke down. Shortly afterward, at the end of 1898, Cohen resigned as manager for De Lamar and was replaced by Victor Clement, who had but lately returned from the Transvaal, where he had been manager of the Simmer & Jack mine. From Gemmell and Jackling he heard about the Wall property; thereupon, early in

1899, he assured Wall that he could guarantee him a square deal, the result being an offer by Clement, for De Lamar, to purchase a quarter for $50,000 outright, with a year's option on another quarter at $250,000, and on a third quarter at $1,250,000. This proposal was accepted by Wall, whereupon De Lamar's engineers started exploratory work, and soon had spent $25,000 in new openings. Samples were taken at intervals of five feet. Jackling, in his report, estimated 12,385,000 tons of ore averaging 2 per cent, besides a probable 25,000,000 tons more. The mine-sampling was checked by mill-tests, using five stamps, two Wilfley tables, and a Frue vanner. The results showed a recovery of 71·70 per cent in a concentrate containing 21·75 per cent of copper. When sold to the Germania smelter, the concentrate was valued at $55·07 per ton, which included payment for 0·12 ounce of gold and 1·40 ounces of silver per ton. Unfortunately, while this examination of the mine was in progress, Clement got into a wrangle with De Lamar, the result being that Clement resigned, and Cohen came back as manager. De Lamar dropped the deal, except for the quarter interest he had bought for $50,000. He had spent $46,000 in the course of the investigation.

Cohen submitted the business to Benjamin Guggenheim in 1900, to Charles A. Coffin, of the General Electric Company, in 1902, and to John Hays Hammond, also in 1902. Indirectly the Utah Copper venture was offered to Marcus Daly in 1901, to the Tharsis Sulphur & Copper Company in 1902, and to William A. Clark in 1903. The fact that a mass of 1½ to 2 per cent copper rock was unattractive 30 years ago should surprise no one; it required constructive imagination of no common order and unusual financial courage to undertake the large-scale exploitation of such a deposit at that time. Both requisites were forthcoming in due course.

Soon after completing his examination of the Wall property, Jackling resigned from De Lamar's employ. In 1901 he went to Colorado Springs, where he became associated with Charles

MacNeill and other friends as consulting engineer to the United States Reduction & Refining Company. At the very start of his career at Cripple Creek in 1894, he had made the acquaintance of MacNeill and also of Spencer Penrose and Charles Tutt, these three being the organizers of the reduction company, which operated two mills at Colorado City, close to Colorado Springs, on ore coming from the mines at Cripple Creek. Jackling was then thirty-two years of age; he had already proved himself a resourceful metallurgical engineer, and he had repeatedly advised De Lamar that the Bingham venture was full of promise. Starting life poor and without friends, he had worked his way to graduation from the Missouri School of Mines. A masterful character, possessed of vigorous initiative, he was beginning to feel his way to his proper position as a captain of industry. He spoke about the Wall property to his associates in Colorado, and they undertook to back him; so, at the end of 1902, while at Salt Lake City on other business, Jackling called upon Wall and tried to obtain an option, but without success. It happened that both Jackling and Cohen were in the town in connection with a suit brought by De Lamar over the interpretation of an electric-power contract made during the time they were in the Captain's employ; so they met. Jackling discussed the question of an option with Cohen, and told him that if he could persuade Wall to grant one, the gentlemen in Colorado would provide the capital necessary to develop the enterprise. Cohen went to Wall and spoke of having New York friends that would be willing to find money for the Bingham undertaking if a reasonable option could be given. Wall was willing to sell half his holdings for $400,000, but he imposed conditions in regard to the equipment and development of the mine; he demanded also that a mill to treat 500 tons daily be built by the supposed New York buyers, who also were to purchase De Lamar's quarter interest. These negotiations were on the point of breaking down when Cohen obtained the help of a local banker, William S. McCornick, who aided him in persuading

Wall to come to terms. On January 23, 1903, Wall signed an option to Cohen on "two-fourths undivided interest" at $350,000 in cash, of which $50,000 was payable on March 9 and $300,000 on June 7 of that year. In this agreement Wall recorded his willingness to join in the organization of a stock company, retaining for himself the right to nominate one member of the governing board. Cohen took the option to Jackling, who took it to MacNeill, in Colorado. Thereupon MacNeill, Spencer Penrose, and his brother R. A. F. Penrose, a distinguished geologist, came with Jackling to Utah and visited Bingham. Cohen's agreement was replaced by a new one, in the name of Spencer Penrose, by the terms of which Wall was to receive $385,000 for 55 per cent of the entire property, and the MacNeill-Penrose group was to purchase De Lamar's quarter, leaving Wall with a 20 per cent holding in both shares and bonds. The option was to be for six months, with the privilege of extension for twelve months more on payment of $5000 in cash for each monthly extension of time. They did use seven months extra, and for that they paid $35,000; so Wall eventually received $420,000 in all. They bought De Lamar's interest for $125,000.

An examination of the mine was made by F. H. Minard, who was selected by R. A. F. Penrose. Minard's report was dated April 23, 1903. It made clear the fact that the porphyry had intruded into the limestone and quartzite, and that the copper was in the porphyry in the form of small particles of copper pyrite, which had undergone leaching and concentration within a zone of enrichment. The leached portion extended for 50 feet from the surface, and within this zone the monzonite averaged 0·75 per cent of copper. The zone of enrichment, underneath, was from 100 to 150 feet thick, with a copper content of 2 per cent, as chalcocite. Below this was the primary deposit, containing 1·1 per cent of copper. Minard's samples were taken with hammer and moil at intervals of 10 feet. Usually each sample weighed 50 pounds. The average of all his samples was 1·6 per cent, and he esti-

mated that the workings disclosed 9,000,000 tons of such copper-bearing rock.

On June 4, 1903, a company named the Utah Copper Company was organized under the laws of Colorado, the capital of this corporation being $500,000 in shares of one dollar each. Then an experimental plant of 300 tons, known as the Copperton mill, was built at Bingham, to ascertain the method best suited to the treatment of the ore. This mill was completed in April 1904. Shortly afterward the company was reorganized; this time it was registered in New Jersey with a capital of $4,500,000 in $10 shares. The date of this incorporation was April 29, 1904. An issue of $750,000 in 7 per cent bonds, to run for three years and convertible into stock at par, was made on July 1. These bonds were largely underwritten by the promoters themselves, for they had been successful in earlier mining ventures and were wealthy men. Here it may be mentioned that $250,000 was all the cash that was put up at the start to launch the Utah Copper enterprise. Wall was left with $150,000 in bonds and 90,000 shares of stock. Jackling and Cohen received a 5 per cent commission, which was paid in stock. They still had to find the working capital—several million dollars—required to develop and equip the mine on an adequate scale.

In the summer of 1904 the purchase of a block of stock was considered by the General Electric Company, on the recommendation of their engineer, D. M. Riordan, after an examination had been made by E. Gybbon Spilsbury and W. Lawrence Austin, who found that at least 5,000,000 tons of 1·98 per cent copper ore had been developed, and reported that the small Copperton mill had been brought to the point of profitable operation. These estimates fully confirmed the earlier figures of Jackling and Minard; nevertheless they were received with scepticism; the directors of the General Electric followed the lead of a member of the board that would "not believe the damn figures". Such undoubtedly was the mental attitude of others to whom the business was presented. In 1906 the

remainder of the original bond issue of $750,000 was retired, at a premium of 5 per cent, to make way for a new issue of bonds, namely, $3,000,000 at 6 per cent, this money being required to build the Magna mill at Garfield, the metallurgical centre of the Utah Copper Company on the shore of the Salt lake. This issue was convertible into stock at $20 per share; it was underwritten by the Guggenheims, in the name of the Guggenheim Exploration Company; and they, at the same time, purchased a block of stock. In February, 1907, Hayden, Stone & Company underwrote the purchase of 60,000 shares of stock at $25 per share, making $1,500,000; and in June, 1908, the same firm of brokers underwrote an issue of $1,500,000 in bonds convertible into stock at $20 per share, the bonds being sold in order to provide funds for expanding the capacity of the mill. Thus the capitalization of the company became augmented to $7,500,000. Two years later, in January, 1910, the capitalization was increased to $25,000,000, of which stock to the amount of $16,244,900 in $10 shares has now been issued. Out of the stock issued in 1910, amounting to $8,282,240, the sum of $3,100,000 was paid for the property of the Boston Consolidated, and $4,455,120 was paid for 1,000,152 shares of Nevada Consolidated, this being a highly successful copper enterprise at Ely, in Nevada. From the day when production began, in 1907, to the end of 1917—ten years—the mine yielded 67,220,700 tons of ore, averaging 1·428 per cent of copper, from which was produced 3,118,385 tons of concentrate averaging 19·81 per cent and containing 617,785 tons of copper. From this output of metal the company was enabled to pay $75,770,882 in dividends and at the same time to accumulate a working capital of $48,293,528. All the estimates of the engineers that best appreciated the capabilities of the mine have been fully confirmed.

Wall was elected a director of the company when it was organized in 1903, but he resigned in 1908, on account of friction with his colleagues on the board. The result of these disagreements was to create bitter feeling between him and

Jackling, a feeling that found vent in a journalistic vendetta; Wall started a paper called 'Mines and Methods', published at Salt Lake City, for the purpose of waging war upon Jackling and his associates. This paper was issued weekly from September, 1909, to August, 1913, and then it went into the limbo of deservedly forgotten things. This animosity on the part of Wall was due not to personal wrong but to intense disappointment in not being made manager of the company and in seeing the credit for the creation of this splendid enterprise pass to Jackling, whose virile personality increasingly dominated the operations of the company. One cannot withhold some measure of sympathy for the old miner, who stuck to his dream so long and showed such patience in consolidating the property first and then in nursing it during the long years of inaction; but such sympathy is not inconsistent with admiration for the persistence and skill of the younger engineer, who, with equal faith in the prospect, brought the dream to complete fulfilment.

In 1929 the output of the Utah Copper mine was 17,724,100 tons, or 50,210 tons *per diem.* While obtaining this ore, 5075 feet of churn-drilling was done, whereby 15,000,000 tons of 1·12 per cent copper ore were developed. The total reserves of ore at the end of the year were estimated at 640,000,000 tons, averaging 1·07 per cent of copper. Nearly 10 million cubic yards of overburden were excavated and removed during the year. The actual mining cost was 12·37 cents per ton, to which 6·40 has to be added for fixed and general charges. The average copper content of the ore was 0·994 per cent, or 19·88 pounds per ton. The average recovery in the form of concentrate at the mills was 85·67 per cent, or 17·04 pounds per ton. The average milling cost for the year was 36·58 cents per ton. The concentrate averaged 32·06 per cent of copper. By precipitation from mine and dump waters there was recovered 4,514,498 pounds of copper. The net production of copper, after smelting and refining, was 296,-625,554 pounds. The average cost, including depreciation

of plant and equipment, and of all fixed and general expenses (except Federal taxes), was 6·65 cents per pound of copper. The importance of a mine such as the Utah Copper to the community in which it is placed is indicated by the fact that the company's assessed valuation for the year 1930 is $92,659,-600, which is equivalent to the tax valuation of 18 of Utah's 29 counties, representing 60 per cent of the State's total area, and to more than one-eighth of the total assessed valuation of the State.

It is important to note that the Utah Copper mine produces gold and silver in quantities sufficient to give it distinction as a source of the precious metals. The output of the three metals respectively in 1929 was:

Copper................	296,625,554 lb.	at 16·749¢	=	$49,681,949·98
Gold..................	116,087·182 oz.	at $20·00	=	2,321,743·64
Silver................	1,050,074·67 oz.	at 53·294¢	=	559,525·42
				$52,563,219·04

On October 31, 1930, Mr. Jackling was awarded the Saunders medal of the American Institute of Mining and Metallurgical Engineers. On that occasion it was stated that the cost of moving material by electric shovels and electric haulage had been reduced to between 12 and 15 cents per ton, and the recovery in the mills had been increased from an average in early days of 60 to 65 per cent of the copper content to a present yield of 85 to 95 per cent. In consequence of these reductions in cost and improvements in metallurgic practice it was possible to exploit profitably surficial ore containing only 0·6 per cent of copper and to mine underground ore containing as little as 1 per cent, whereas in the early days of the Utah Copper enterprise no rock containing less than 1·5 per cent of copper could be considered as 'ore'.

From July 1, 1904, to November 30, 1930, both inclusive, the Utah Copper mine yielded 201,623,974 tons of ore, from which 3,601,371,703 pounds of copper were extracted. The gross value of the metals contained in the mill ore was $839,718,009,

and out of this the shareholders received $215,477,022 in dividends.

The costs of operation in 1929 were as follows:

Distribution	Per dry ton of ore	Per pound of net copper
Mining (and stripping)	$0·4121	$0·02500
Milling	0·3658	0·02219
Ore delivery	0·0896	0 00543
Treatment, freight, and refining	0·3765	0·02284
Selling expense	0 0206	0·00125
	$1·2646	$0·07671

Perhaps a hundred years hence these figures* will not seem so remarkable as they seem to us today, but assuredly if our grandfathers, in, say, 1850, had been given a glimpse of this page they would have marvelled so greatly as to be incredulous.

* For which I am indebted to David D. Moffat, the General Manager.

CHAPTER IX

THE BLACK HILLS OF SOUTH DAKOTA

The Black hills rise like a dark island above the far-flung prairie lands of the Dakotas; to their sombre pine-clad slopes they owe the name, Black mountains, by which they were known to the early explorers. Pahasapa, a Sioux word with the same meaning, was the name given to these hills by the Indians, who avoided them, believing them to be mysterious and dangerous. The aborigines entered the hills rarely, to pick berries, hunt the deer, or to cut lodge-poles, the central supports of their huts.

The French explorer Pierre de la Veréndrye reached Dakotan soil in October 1738, coming thither from Montreal by way of Lake Superior and the Lake of the Woods.* Five years later his sons, François and Louis Joseph, reached the Black hills, as is recorded on a plate unearthed at Fort Pierre in 1913. The French-Canadian explorers and trappers of that time, however, appear to have been diverted southeastward to the more promising lands of the Mississippi valley, so that we find no mention of the Black hills in the chronicles of the period until Lewis and Clark, on their way to the Pacific coast, in 1805, met a French trader, named Jean Vallé, on the lower Cheyenne river, and from him they heard of the Black mountains in a casual manner. Next, Wilson P. Hunt, who, at the head of an expedition crossed the Rocky Mountains on his way to the Astor trading-post on the Columbia river, in 1811, had a glimpse of the dark hills to the north, but that was all. Then in 1823 Jedediah S. Smith, one of the earliest discoverers of gold in California, crossed the southern part of the Black hills on his way westward. Two trading-posts were established in

* Agnes C. Laut, 'The Blazed Trail of the Old Frontier', p. 33; 1926.

1828 on the Belle Fourche and White rivers for the purpose of obtaining furs from the Indians, and for the first time we hear whispers of gold having been found in these parts.

It is a tradition in the Northwest that Father Pierre De Smet, a Belgian Jesuit, in the course of his missionary work among the Indians, in the years 1846–1849, learned that gold was to be gathered in the hills, and advised the Indians to say nothing about it,* for fear of bringing a horde of prospectors into their country. General Sheridan, who knew the priestly explorer, learned something of the sort from him, for, when writing to General Sherman, in March, 1875, he said that "while living with the Sioux Indians he [De Smet] was shown by them nuggets of gold, which they informed him had been obtained at different points in the Black Hills . . . and on his representation that such yellow metal was of the greatest value, they told him that they knew where there was a mountain of it". Subsequent investigation, however, proved that the Indian mountain of gold was nothing more than a formation of yellow mica.† It is said that in 1867 the Indians agreed in council not to reveal the presence of gold in the hills and stipulated that any one of them that did so was to be killed, "for fear the country should be taken from them"; so said Sitting Bull, the Sioux chief.‡ It was Custer, whom he vanquished, that was the first to make known the occurrence of gold.

Such recognition as the region obtained among men of education a hundred years ago was due chiefly to the fossils that the fur-traders began to bring from the hills and to the descriptions of them that appeared in scientific journals. For example, Hiram A. Prout, in 1846, described a gigantic palaeotherium from the bad lands of southern Dakota in the

* H. M. Chittenden and A. T. Richardson, 'Father De Smet's Life, Letters, and Travels', Vol. IV, p. 1522; 1905.

† Henry Newton and Walter P. Jenney, 'Report on the Geology and Resources of the Black Hills of Dakota', U. S. Geol. Survey, p. 17; 1880.

‡ George W. Kingsbury, 'History of Dakota Territory', Vol. I, p. 966; 1915.

'American Journal of Science'. In 1855 a military expedition, commanded by General Harney, was accompanied by several scientific observers, among them being Ferdinand V. Hayden, who began a geologic exploration of the Hills, and drew attention to them as an interesting subject of study. In 1866 he stated before the Dakota Historical Society that he had seen some little specks of gold along the foothill streams, and he expressed the opinion more than once that there were chances of finding gold in some quantity in the mountains; but, apparently, at no time did he trouble to follow the clue. Rumors of gold in the Black hills, however, were frequent, and it became customary for the Territorial governors of Dakota to allude to the matter vaguely, but with increasing assurance, notwithstanding the complete lack of evidence.

The country was within Indian territory; by the treaty of 1867, ratified by the Federal government, the Black Hills region was within the permanent reservation set aside for the Dakota, Kiowa, and Sioux tribes. They denied entrance to their domain. The Laramie-Bozeman trail, planned in 1865 as a route to the goldfields of Montana, cut across the buffalo grounds of the Sioux reservation, and we need not be surprised to find a statement that a renowned chief, Red Cloud, made it "a route of massacre" for the gold-seekers on their way westward. The Government at Washington tried to prevent conflicts between the whites and the Indians, but the increasing curiosity concerning the Black hills and the popular desire to have the region opened to settlement could not be controlled, whereupon those in authority decided to send a military expedition to explore the country and to establish central fortifications for the protection of travel. Such were the conditions when, in 1874, General George A. Custer was directed to organize an expedition for the purpose of establishing a route to the Black hills. This expedition was most successful; the information gathered by the newspaper correspondents and scientific observers was given wide publicity. Few Indians were seen, and those that were encountered evidently were

much surprised by the imposing cavalcade, with its artillery and hooded wagons. On July 30 the expedition halted in a natural park near the granite ramparts of Harney's Peak, and

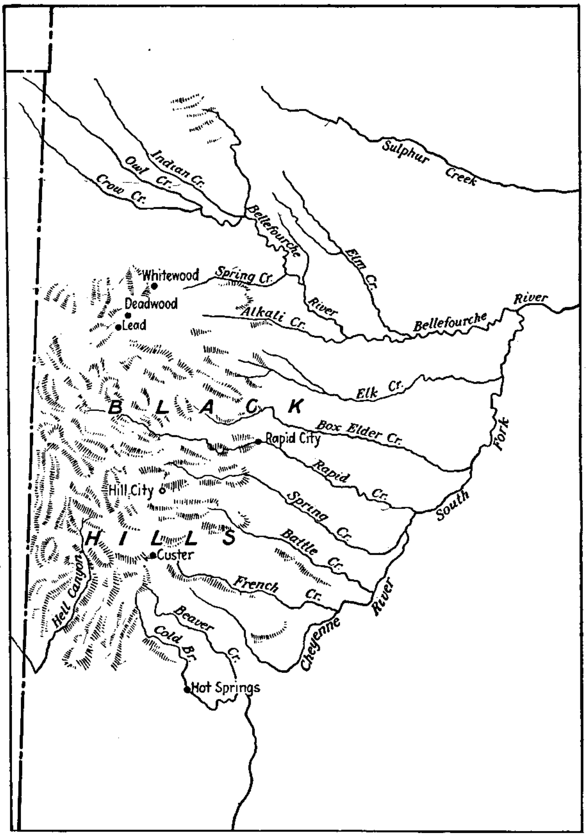


FIG. 16.—The Black Hills district. (*From 'New International Encyclopedia,' courtesy Dodd, Mead & Company, Inc.*)

some prospecting was done during the interval of three days. "The gold-seekers who accompanied the expedition", says N. H. Winchell, the geologist, "report the finding of gold in the gravel and sand along this valley." The place was on

French creek, where Custer City was built later. The discovery of gold was made by Horatio Nelson Ross, an experienced miner, on August 1, 1874.

Another story of the first discovery of gold is told by Jenney, as follows: Toussaint Kensler, a half-breed Indian, who had worked in the gold placers of Alder gulch, in Montana, was in prison, under sentence of death, when he escaped. He disappeared for a long time, and when he re-appeared at the Indian agency he had in his possession a number of goose-quills filled with gold-dust, which he claimed to have obtained in some diggings that he had discovered. He was re-arrested, and in due course he was hanged; but before his execution he drew a map of the locality in which he had found the gold and also showed the route he had traveled, together with the distances and names of creeks he had crossed. His sketch, says Jenney, who had it in his possession, indicated that the place was either on Amphibious or on French creek, probably the former.* Both these creeks drain the southern part of the natural park to which Custer's name was given because he camped there in 1874.

Even this does not exhaust the list of probable first discoverers of the gold, for, in still earlier days, the Hills were prospected by adventurers that never returned. In 1887 a flat stone found near Spearfish disclosed an inscription: "Came to these hills in 1833, seven of us De Lacompt Ezra Kind G. W. Wood T. Brown R. Kent Wm King Indian Crow all ded but me Ezra Kind killed by Indians beyond the high hill got our gold June 1834". On the reverse was written: "Got all the gold we could carry our ponys all got by the Indians I have lost my gun and nothing to eat and Indians hunting me". Not far away were some camp utensils so much rusted as to indicate long abandonment. Some of the names are said to have been identified by kinsmen;† nevertheless, the story

* Walter P. Jenney, 'Report on the Natural Resources of the Black Hills of Dakota', Sen. Doc., No. 51, 44th Congress, p. 51; 1876.

† Jesse Brown and A. M. Willard, 'The Black Hills Trails', p. 29; 1924.

must be regarded as an amusing concoction. At other places, it is said, tools, ruined shelters, and other evidences of forgotten pioneers, the victims of the Indians, have been found.

General Custer, in his record under date August 2, 1874, says: "I have upon my table forty or fifty small particles of pure gold, in size averaging that of a small pin head, and most of it obtained today from one panful of earth". On August 15, in a dispatch sent from Bear Butte, Custer said: "Subsequent examinations at numerous points confirm and strengthen the fact of the existence of gold in the Black Hills. On some of the water courses, almost every panful of earth produced gold in small, yet paying quantities. Our brief halts and rapid marching prevented anything but a very hasty examination of the country in this respect; but in one place, and the only one within my knowledge where so great a depth was reached, a hole was dug eight feet in depth. The miners report that they found gold among the roots of the grass, and, from that point to the lowest point reached, gold was found in paying quantities. It has not required an expert to find gold in the Black Hills, as men without former experience in mining have discovered it at an expense of little time or labor".*

There was great excitement in the camp when it was announced that gold had been found, and all the cooks were importuned to lend pans, dishes, and buckets to the many men that were eager to try their luck. William E. Curtis, correspondent for the 'Chicago Daily Tribune', wrote on the seventh of August to say that the first mining district in the Black hills was organized at this time, on French creek, and that the meeting was held around a camp-fire surrounded by wagons. The discovery claim was granted to Ross, and No. 4 below discovery went to his partner, William T. McKay. Twenty claims were located. It was a romantic gesture, and nothing more. The locations had no validity, the land

* George W. Kingsbury, 'History of Dakota Territory', Vol. I, p. 889; 1915.

belonged to the Indians, and the Government at Washington was not prepared to aid such trespass on their domain.

It is tempting to compare General Custer and his men with other military expeditions into mining regions. Alexander the Great during his Indian campaign was accompanied by Gorgus, a miner, who found gold and silver in the country of the Sopiethes, the modern Punjab. So says Strabo;* but Herodotus,† and, later, Arrian, unite in contradicting this statement and in asserting that the Indian tribes whom Alexander encountered were without gold. In later days the expeditions of such conquering freebooters as Cortés and Pizarro were unaccompanied by mining experts; instead, the *conquistadores*, in their invasions of Mexico and Peru, looked for gold in the graves and temples of the natives, and for such looting it was not necessary to employ the miner; they sought for gold and silver with the sword, not the pick.

News of the discovery of gold spread fast and incited a rush to the Black Hills, as was to be expected. A civilian party of 28 persons, headed by John Gordon, came from Sioux City, Iowa, and followed Custer's trail to French creek, where they easily found the place where the General's camp-followers had made their discovery. They arrived in December, 1874, and became the first settlers in the new Eldorado. It is significant that they proceeded at once to build a stockade, for defence against the Indians. But before the redmen attacked them, the Government, bound by the treaty of 1867 to prevent such incursions of the whites, sent a troop of cavalry to round up this prospecting party and brought them, in April, 1875, to Fort Laramie in Wyoming. However, the tale told by these adventurers about the gold they had seen gave added zest to the spirit of adventure aroused in the adjacent regions, and caused others to penetrate into the proscribed area. In the summer of 1875 the Government again sent small military detachments to remove such unauthorized gold-seekers, but

* Strabo, XV, 1, 31.

† Herodotus, III, 106.

they continued to evade the lax military surveillance, and filtered slowly into the hills along the trail made by their forerunners. As Richard E. Curran sings:

An old trail, a bold trail
  The old French trappers knew,
A far trail and a war trail
  Through the land of the fighting Sioux;
A rough trail, once a tough trail,
  Where oft the war-whoop thrills,
The gold trail is a bold trail
  As it bears to the far Black Hills.

Other prospectors soon came by way of Sidney, Nebraska, and Cheyenne, Wyoming. The troops were withdrawn from the Hills; in consequence, during the spring and summer of 1875 there was a continuous stampede to the diggings. Early in 1876 an attempt was made to establish a stage-line from Cheyenne to Deadwood, but the hostility of the Indians made it utterly impracticable.

Custer's expedition in 1874 was an infraction of tribal rights as defined by the treaty of 1867, creating the Indian reserve in Dakota; therefore the march of the soldiers across their territory angered the Sioux. Some adjustment of Indian rights was imperative. President Grant caused a commission to be appointed for the purpose of negotiating a treaty with the Indians. On September 20, 1874, a grand council convened. The chairman of the commission, William B. Allison, finding it hopeless to secure title to the soil, said to the redmen: "We have now to ask you if you are willing to give our people the right to mine in the Black Hills, as long as gold or other valuable metals are found, for a fair and just sum. If you are so willing, we will make a bargain with you for this right. When the gold or other valuable minerals are taken away, the country will again be yours to dispose of in any manner you wish". This is not all that he said, of course, but it was the main proposal. One can not read it without smil-

ing—a sardonic smile. The Indians could not agree, but the majority, including most of the younger men, were opposed to a sale at any price. The negotiations failed; gold-seekers continued to come into the hills, all military interference having been withdrawn. Stray parties of prospectors were ambushed and killed by the Indians. Meanwhile the Government, perplexed by the state of affairs, decided to send a party of geologists and topographers to investigate. Walter P. Jenney, accompanied by Henry Newton and other scientific men, made an examination of the Black hills in the period between April and October, 1875. Jenney reported: "There is gold enough to thoroughly settle and develop the country, and after the placers are exhausted, stock-raising will be the great business of the inhabitants, who have a world of wealth in the splendid grazing of this region". It is curious that he, a geologist, should have overlooked the probable exploitation of the veins and lodes from which, by erosion, the gold of the placers had been derived. This scientific reconnaissance collected much useful information concerning the region, but, of course, could do nothing to settle the basic question of land ownership. The Indians were rampant, they resented the disregard of their rights. They had three or four thousand warriors afield. Then, suddenly, came the appalling news that a force of 300 soldiers under the command of General Custer had been surrounded by the Indians and completely destroyed on June 25, 1876, near the Little Big Horn river.

After the Custer disaster the new mining-camps were in constant danger of Indian attack, and several small parties of prospectors were killed. Raids on the horse herds were frequent, and cattle also were stolen by the natives. In August, 1876, General Crook came to relieve the people of the Hills. On his way he scattered an Indian force that opposed him at Slim Butte on September 19, and after a few of their villages had been destroyed by the troops, the Indians were offered a settlement, for which, defeated and dispirited, they were quite ready. In October the Sioux, Cheyennes, Ogallalas, and

Arapahoes signed a treaty of peace, by which, in return for sundry concessions, they were withdrawn from the Hills. This treaty was approved by President Grant on February 28, 1877. General Crook and his troops proceeded to Deadwood, and other mining-camps, where they were received joyously by the happy diggers.

In 1921 a suit was brought by the Sioux Indian tribes for possession of the Black Hills, the claim involving about a billion dollars. For 20 years or more the Sioux had threatened to start litigation, and finally they engaged Charles E. Hughes, Jr., the son of the Secretary of State at Washington, to begin proceedings, on the plea that they had never ceded their trans-Missouri hunting-grounds to the whites, and that the treaty approved by the Congress in 1877 was at variance with the terms agreed upon at the open conference in 1874 with the commission headed by Senator Allison, as already recorded. The Sioux wanted a refund of $400,000,000 on the Homestake mine alone. We may presume that nothing came of this proposed lawsuit, but the historian may take note of it, as indicating that the Indians thought that they were misled.

In 'Scribner's Monthly' there is an account of Deadwood as seen by Leander P. Richardson in August, 1876.* He writes:

"The Deadwood ground is all taken up, and men do not dare to go out prospecting away from the main body, on account of the Indians. Summed up briefly, the condition of mining affairs is this: placer mines all taken up; quartz mines the only resource left. In order to work these, capital, machinery, and mills for the crushing of the ore must be introduced. Men of wealth will hesitate about sending capital into a country so far from railroad communication, and about which so little is definitely known. Most of the men now in the Black Hills are laboring men, inexperienced as miners. Their chances for employment in the mines, then, are small, and their prospects in quartz mining are even poorer.

* *Scribner's Monthly*, Vol. XIII, p. 756; 1877.

The mineral riches of the Black Hills cannot be developed for fully twenty-five years to come . . . Farming there is out of the question. Throughout a greater part of the district heavy frosts begin in September; snow-storms did not cease last spring until the eleventh day of June. Every farmer will see that a country where winter reigns from September to June cannot support its inhabitants upon its agricultural products."

This magazine writer was depressed by the hardships he had experienced, and by bad weather, to such a degree as to prove himself a foolish pessimist. The quartz mining developed into a major industry, as we shall see, and the severity of the climate was no hindrance to the profitable cultivation of wheat and other grains. Evidently he did not know how ordinary "laboring men" under experienced supervision can be trained to become efficient miners in a short time. They found ample scope for their service when the Homestake, Caledonia, Father De Smet, and other big mines started to work. In 1877 the Black Hills district yielded $2,000,000 in gold; in 1880, the yield was $3,300,000. The total production of gold has been $287,500,000.

From the date of the discovery of gold until the President's proclamation declaring the Black Hills to be national territory, the pioneers, as we have seen, were trespassers upon the Indian lands and were compelled both to fight the natives and to dodge the military police of the United States government. They persisted in coming, however, and in staying. Camps were established at Bear Rock, Whitewood, Deadwood, Gold Run, and Palmer Gulch. Frank Bryant and his partners washed the first gold on Whitewood and Deadwood gulches in August, 1875, but they did not find the gravel good enough to satisfy them. In November, however, a party led by William Lardner staked a rich discovery claim at the mouth of Blacktail ravine in Deadwood gulch, and with this successful venture the mining industry of South Dakota may be said to have been born. In three months the locators collected

$27,000. To the diggings at this time came also the Wheeler brothers, experienced miners, who in the fall of 1876 sold their two claims, from which they had taken $150,000 in gold-dust. The rumors of rich finds incited a stampede to Deadwood, and soon the confusion caused by the careless location of claims was followed by numerous controversies, involving gun-play, fortunately harmless in most cases.

The most important location to be made during those hectic days was the claim that became the Homestake mine. The discoverer was Moses Manuel, a prospector, who heard of the Black Hills on his return from Alaska in the fall of 1874, and, attracted by the reports of Custer's expedition, made his way alone over the mountains from Portland, Oregon, to Helena, Montana. There he met his brother Fred, who accompanied him to the Hills, by way of Green River, Laramie, and Cheyenne. They reached Custer City in December, 1875, but finding nothing of promise there they proceeded to Whitewood creek, halting at other places to prospect on their way. At Whitewood there was much excitement, because the placer diggings were rich; they were enriched by the erosion of the schist lodes and of a gold-bearing conglomerate of later origin that capped the hillsides above the gulches. The Manuel brothers camped in Bobtail gulch and engaged in gravel mining, because the snow made hillside mining impracticable; but a lode claim, the Golden Terra, had been located, and a two-thirds interest in it was bought by the two brothers, and their partners Hank Harney and Alex Eng. Moses Manuel, fortunately, has told the story of the discovery of the Homestake lode. It came about in this wise:

"Toward spring, in the latter part of March or April, four of us found some rich quartz. We looked for the lode, but the snow was deep and we could not find it. When the snow began to melt I wanted to go and hunt it up again, but my three partners wouldn't look for it, as they did not think it was worth anything. I kept looking every day for nearly a week, and finally the snow got melted on the hill and the water ran

down a draw which crossed the lead, and I saw some quartz in the bottom and the water running over it. I took a pick and tried to get some out, and found it very solid, but I got some out and took it to camp and pounded it up and panned it and found it very rich. Next day Hank Harney consented to come and locate what we called the Homestake Mine, the 9th of April, 1876." The claim covered only 75 feet on each side of the vein and was 1350 feet long, so as to cover nearly 4⅔ acres.*

As soon as the location had been made, Manuel and his partners started to sink a discovery shaft, and the first lump of quartz, weighing about 200 pounds, was one of the richest that ever came out of the lode. Next day they began to dig an open-cut, and found that the ore was both wide and rich. To treat their output they built an arrastra on Whitewood creek and made a road, over which the ore was brought in a wagon pulled by oxen. With this equipment they extracted $5000 in gold during the winter of 1876–1877. In the spring the four partners sold the Golden Terra to John Bailey, of Denver, and the Durbin brothers, of Cheyenne, for $35,000, so that now they had ample working capital.

A ten-stamp mill was built and a half-interest in a saw-mill was acquired. Meanwhile, on another claim, the Old Abe, an orebody had been found in the course of preliminary exploration. They had given an option on both the Homestake and the Old Abe, but both options had expired without a purchase; and now they felt justified in asking bigger sums for these two claims. George Hearst took an option on the Homestake at $70,000 for 30 days, and a few days later Huron offered $45,000 for the Old Abe. In due course, both these transactions were consummated.

It is interesting to note that the Homestake claim itself and the Golden Star claim, purchased at about the same time, covering together 1350 feet by 450 feet, constituted the entire property of the Homestake Mining Company when it

* Richard Blackstone, *The Pahasapa Quarterly*, Vol. V, p. 18; 1916.

was incorporated on November 5, 1877, by James B. Haggin, George Hearst, and Lloyd Tevis. The enterprise was capitalized at 100,000 shares of $100 each, and an assessment of $200,000 was levied immediately to build a mill of 80 stamps, which started to crush ore on July 12, 1878. The results were so satisfactory that the construction of a second mill, of 120 stamps, was started six months later, to be completed on September 1, 1879.

The first report of the company stated that the 80-stamp mill, between July 12, 1878, and April 1, 1880, crushed 110,000 tons for a yield of $923,389, or an average of $8·40 per ton. The ore came from an open-cut and was hauled to the mill by horse-wagons until April 1879, when a small Baldwin locomotive came into use. Extreme cold (27 degrees below zero, Fahrenheit) stopped the milling repeatedly during the winter of 1877–1878, because arrangements for heating the building were inadequate. However, this was soon corrected by the energetic superintendent, Samuel McMaster, a big Irishman, who had obtained his experience in the mines of Australia and California.

In the first report it is said: "The gold is mostly coarse and easily saved in the batteries. The ore is in the highest degree free milling, even that from the lower levels [200 feet] with several per cent of pyrite is readily amalgamated, the concentrates showing but $8 per ton. The average loss, while working ores containing $8 to $10 per ton is but $2·00, indicating a yield of 75 to 80 per cent . . . The average yield up to June, 1879, was $9·69 per ton. Milling all the rock between walls has lowered the grade, while reducing the cost of mining. The yield from Sept. 1879 to Feb. 1880 was $4·25 to $5·60 per ton, it now averages $7·95. Blankets and concentrating machinery are not employed; the most perfectly concentrated tailings will not assay more than the rock from which they are derived. The loss of quicksilver is but 0·16 ounce per ton". That tells the story plainly and truly. The Homestake ore was simple in character and admirably adapted

to stamp-milling, plus amalgamation. Nowhere has the stamp-mill been used so effectively as at Lead City, which is the town that has been built near the great mine. The enterprise flourished. Three distinct periods in the life of the Homestake mine are recognizable, the first being one of development, from the start to 1890; the second was a period marked by expanding operations and the acquisition of adjoining properties; the third from 1910 to date has been distinguished by mechanical and metallurgical improvements, accompanied by a steady fruition of profit.

In the early days of the company the management had to face many difficulties that belong entirely to a romantic past. Machinery and supplies were brought in ox-wagons, and passengers traveled in stage-coaches from the nearest railroad points, at Cheyenne, Sidney, and Bismark, but not without an occasional unpleasant, if picturesque, interruption caused by Indians and by highwaymen. Supplies reached the mining-camps so irregularly that sometimes the miners were glad if only the flour and bacon did not run short. Game hunted in the Little Missouri region was frequently of timely value to the hungry gold-seekers. Snowslides and fires punctuated the life of these frontier communities, and an occasional shooting scrape betokened the lawless spirit of reckless men.

Shaft-sinking and underground development followed the open-cut mining at an early date—probably too soon, for it would have been cheaper to remove much more of the lode by daylight. The underground methods copied those of the Comstock, including the carpenter's idea of square-set timbering; but stoping without timbering was soon adopted in the Caledonia mine, and shrinkage stoping was introduced in the Deadwood Terra shortly afterward. The mill capacity was increased steadily, without increasing the number of stamps, from 2½ to 4 tons per head, by changing the design of the mortar and by increasing the weight of the stamps. During this early period there was intense rivalry between

the neighboring companies and an eager scramble for water-rights. These conditions were ended by a consolidation of properties, the Homestake company absorbing its neighbors. Thereupon the shafts were deepened to 1700 feet and the mills were increased to 1000 stamps, whereby over 4000 tons of ore was treated daily.

The Black Hills region, occupying an area of 5000 square miles, geologically consists of an Algonkian island flanked by later sedimentaries, many of them metamorphosed; topographically the Hills consist of a dome of granite and schist surrounded by foothills of limestone and sandstone, rising above the wide plains of the upper Missouri. The gold of the Homestake lode occurs in large bodies of quartzose chloritic schist, originally a ferruginous dolomite, conforming to the structure of the enclosing Algonkian slate and schist. The width of the milling ore varies from 50 to 400 feet. The area that has been proved to be gold-bearing is about a mile and a half long by half a mile wide.

In 1888 the Homestake company milled 243,355 tons for a yield of \$3·71 per ton and at a cost of \$2·52 per ton, the profit therefore being \$1·19 per ton. In 1895 the Homestake company was operating two mills, one of 100 and another of 160 stamps. Each stamp weighed about 880 pounds and dropped 85 to 88 times per minute. The height of drop was 9½ inches and the depth of discharge varied, as the die wore down, from 9 to 11 inches, an effort being made to maintain a nearly uniform depth by means of chuck-blocks. Inside the mortar there was one amalgamating plate, of plain copper, 5 inches wide, in front. The screens were of No. 8 Russia iron punched with diagonal slots so as to be equivalent to a 30-mesh wire. Mercury was fed into the battery in proportion to the richness of the ore, as indicated by the condition of the amalgam on the apron plates. The aprons were 10 feet long and 4½ feet wide; two of them discharged upon one tail-plate of the same size. All the plates were of plain copper. Then came traps to arrest amalgam. No serious effort was made to concentrate

the sulphide minerals (iron pyrite, pyrrhotite, and mispickel) associated with the gold; the two mills respectively had only six and eight crude bumping tables for this purpose. The ore was crushed at the rate of four tons per stamp, at a cost of 85 cents per ton in the smaller mill and of 70 cents in the larger one. During the year ending June 1, 1894, the two mills treated 309,210 tons yielding $1,390,610, or $4·50 per ton of ore. The extraction was about 75 per cent.*

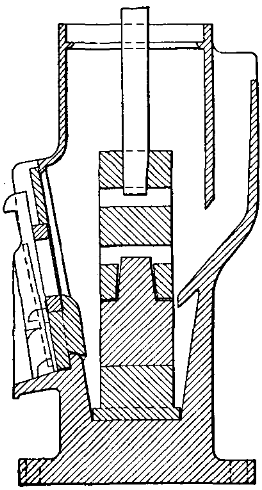


FIG. 17.—The Homestake mortar.

It may be said fairly, I think, that the stamp-mill as a combined ore-crushing and gold-saving device was never put to more successful use than by the Homestake company. This success was due in large part to the design of the mortar, which combined two excellent features: an opportunity for amalgamation and a rapid discharge of the pulp. The narrowness of the mortar hastens discharge and gives a capacity nearly twice that of the ordinary Californian battery; the depth of the Homestake mortar prevents scouring of the inside plate and permits the arrest of the gold on this plate, as well as by the free mercury added with the ore as it is fed into the mortar.†

This practice was described by unfriendly critics as exemplifying "haste and waste",‡ because the ore was rushed through the mills and no serious attempt was made to save the concentrate. This criticism was itself hasty, and perhaps wasted

* T. A. Rickard, 'The Stamp Milling of Gold Ores', p. 98; 1897.

† T. A. Rickard, *Trans.* Amer. Inst. Min. and Met. Eng., Vol. XXV, p. 913; 1896.

‡ C. G. Warmford Lock, *Trans.* Inst. Min. and Met., Vol. III, p. 171; 1895.

also. During 1894 the saving of concentrate was 457 tons having an assay-value of $6 per ton, on which the company realized about $2 per ton when sold to the Delaware smelter below Deadwood. The chief loss in the tailing was in the form of amalgam and floured quicksilver. The truth is, the ore was easy to crush, the gold was readily liberated for amalgamation by the fine grinding in a deep mortar, and it could be treated so rapidly and so cheaply as to yield a handsome profit. The milling practice, as I remarked in 1895,* from a technical standpoint might be deemed inadequate, but from a business point of view—and the primary purpose of mining is to make money—it was justified by the financial results. As was remarked by another commentator, apropos of such criticism, in 1912: "The fact remains that for over 30 years, with an ore uniformly of low grade and in a region of high wages and high freight rates, this company has, with the exception of three brief cessations due to extraneous causes, kept its mills running and paid dividends which now aggregate over $27,000,000, the output having passed the $100,000,000 mark".†

By that time, 1912, the Homestake company was operating six mills dropping 1000 stamps altogether. The total cost of milling in the 200-stamp mill had been decreased to 40 cents per ton.‡ The speed, drop, and discharge were about the same as before, but silvered plates had largely replaced the plain copper, and the tables for amalgamation had been greatly enlarged. The apron plates were in four rows, each 55 by 144 inches, so that an amalgamating surface of 55 square feet was provided for each stamp. The plates were silvered to the amount of two ounces of silver per square foot. The recovery by amalgamation was 72 per cent of the

* *Engineering and Mining Journal*, Vol. LX, p. 251; 1895.

† Allan J. Clark and W. J. Sharwood, *Trans.* Inst. Min. and Met., London, Vol. XXII, p. 68; 1912.

‡ Charles W. Merrill, *Trans.* Amer. Inst. Min. and Met. Eng., Vol. XXXIV, p. 587; 1904.

gold in the ore. Moreover, the cyanide process had been introduced by Charles W. Merrill in 1899. The first thing done was to classify the tailing by means of cones, from which the slime was discarded. The essentials for effective cyanidation are classification and aeration, the ferrous salts, detrimental to the process, becoming oxidized thereby.* For six months the cyanide recovery was 74·7 per cent, on the sand, which averaged $1·20 per ton; but the slime, which assayed 80 cents to $1·10 per ton, was not as yet subjected to treatment. This step was taken in 1906, when the Merrill filter-press was introduced, followed by the use of zinc-dust for precipitation. Re-grinding of the coarse portion of the tailing was started in 1908, by means of pans and tube-mills, the recovery being increased thereby so that in 1912 the total recovery by the mill was well above 90 per cent, of which 13 per cent was effected by the treatment of the sand and 7 per cent by the treatment of the slime. This was done on an ore containing $3·60 in gold.

The report for the year 1929 shows that 1,437,935 tons of ore was milled for a yield of $4·53 per ton, or a total output of $6,517,838. Dividends amounting to $1,758,120 were paid from a revenue of $2,473,196. The company had 251,160 shares of $100 par value. There were 15,176,740 tons "blocked out and remaining in the mine". Development at the 2600-foot level was proceeding "satisfactorily and with encouraging results". The report is curt, and does not go into details, as is usual when a mine is controlled by a small group, not looking for public support. Up to June 1, 1900, the mines of the Homestake company had yielded $59,246,340, out of which $15,445,468 had been paid in dividends. From 1900 to 1912 the consolidated company produced $55,987,490, and paid $12,293,400 in dividends. Since then the output of gold has been steadily about $6,000,000 per annum, permitting about $1,750,000 to be paid yearly in dividends. In

* Allan J. Clark, *Trans.* Amer. Inst. Min. and Met. Eng., Vol. LII, p. 77; 1916.

1930 the production was \$8,667,515, the largest on record, the yield having been \$6·175 per ton, or 30 per cent better than in any year since 1910. The reserves are given as 15,657,561 tons. The total production to April, 1931, has been 59,000,000 tons, yielding \$233,564,312 from which dividends of \$57,868,684 have been paid.*

* Cleophas C. O'Harra, president of the South Dakota School of Mines, issued an invaluable bibliography of the geology and mining of the Black Hills in May, 1917.

CHAPTER X

THE COPPER OF LAKE SUPERIOR

The first mention of the occurrence of native copper near Lake Superior is found in a book by Lagarde, published in 1636. The letters of the Jesuit missionaries in the seventeenth century refer to the use of this copper by the Indians. Francesco Bressani, an Italian friar, says, in 1653: "There is a copper ore, which is very pure, and which has no need of passing through the fire; but it is in places far distant and hard to reach. We have seen it in the hands of the barbarians".* Father Jerome Lalemant, writing in 1659, says that the coast of Lake Superior is "enriched with copper of such excellence that pieces as large as one's fist are found, all refined".† These pieces of copper were hoarded by the Indians as mascots. The mention of the metal as having been already refined by nature recalls the fact that the old Greek historians spoke of gold-dust as being *apuron*, or not needing the fire. Father Claude Allouez,‡ writing in 1666, says: "One often finds at the bottom of the water [of Lake Superior] pieces of pure copper, of ten and twenty *livres* [pounds] weight. I have several times seen such pieces in the savages' hands; and since they are superstitious [as if the *padres* themselves were not!], they keep them as so many divinities, or as presents which the gods dwelling beneath the water have given them, and on which their welfare is to depend. For this reason they preserve these pieces of copper, wrapped up, among their most precious possessions".

* Reuben G. Thwaites, 'The Jesuit Relations and Allied Documents', Vol. XXXVIII, p. 243; 1899.

† *Ibid.*, Vol. XLV, p. 219.

‡ *Ibid.*, Vol. L, p. 266.

In two 'relations' by different writers one finds mention of the famous mass of copper on the Ontonagon river. Father Claude Dablon, in 1671, speaks of it as "that great rock of copper, seven or eight hundred *livres* in weight, seen so near the head of the Lake by all who pass". This, and "the numerous pieces found at the water's edge in various places" led him to conclude, logically, that "there are parent mines to be discovered".*

Among those that accompanied the Jesuit missionaries were lay brothers that knew something about metal-work and were competent to make copper castings in a crude way. They did not have to smelt the ore, but only to melt the metal already provided in an elemental condition by the agencies of nature. These pioneer metallurgists used the copper to fabricate crucifixes and for making the medals that the missionaries awarded to their converts.

In 1765 Alexander Henry, an Indian trader, who had come from England to North America soon after the conquest of Canada by the British, traveled through the Lake Superior country, and recorded his observations, among which was "the abundance of virgin copper". He states that the Indians "were used to manufacture this metal into spoons and bracelets for themselves",† from which it is evident that their early veneration had been succeeded by utilitarian ideas. He remarks that "in the perfect state in which they found it [the copper], it required nothing but to beat it into shape". In 1766 he went up the Ontonagon river to see the copper boulder of which the Indians had told him. Its weight he estimated at 5 tons. "Such was its purity and malleable state, that with an axe I was able to cut off a portion weighing a hundred pounds". This mass of copper was removed to the Smithsonian Institution at Washington in 1843 at a total

* *Ibid.*, Vol. L, p. 99.

† Alexander Henry, 'Travels and Adventures in Canada and the Indian Territories', edited by James Bain, p. 186; 1901.

cost of $3500. It weighs 6500 pounds.* Close to it were found numerous stone hammers; and the boulder itself bears many chisel marks; which goes to prove that both red and white men had tried to chip portions of it during the long time it had lain exposed on the river bank.

Whether the Indians did any mining for copper before the European arrived on the scene is doubtful, but we have abundant evidence that they did detach pieces of metal from the big masses that lay in sight and that they would go so far as to dig a trench to get at the less accessible projections of metal. To utilize the copper of the large masses, the Indian belabored the protruding parts with his hammer, and if there was no natural protrusion he would make one by pounding on the edge of the mass until he formed a piece that could eventually be disengaged. He worried such pieces of metal apart by aid of a stone maul weighing from 5 to 15 pounds, like those found in the ancient copper mines of Wales and Spain.† In an old trench that had been dug in the outcrop of the Minesota lode the early American prospectors found a mass of copper, weighing 11,585 pounds, that the aborigines evidently had tried to remove; they had raised it five feet along the slope of the vein by aid of logs, and had then abandoned the attempt. It is noteworthy that "they had taken off every projecting point which was accessible, so that the exposed surface was smooth".‡ More than ten cartloads of stone hammers were gathered in the vicinity, together with numerous stone gads. The hammers were merely water-worn boulders of hard rock around which a groove had been made for the attachment of withes, or water-soaked twigs, that served as a handle. One of these stone mauls, with double grooves, weighed 36 pounds,

* Charles Moore, 'The Ontonagon Copper Boulder', U. S. National Museum; 1897.

† T. A. Rickard, 'The Early Use of the Metals', *Journal* of Institute of Metals, Vol. XLIII, No. 1, p. 302; 1930.

‡ J. W. Foster and J. D. Whitney, 'Report on the Copper Lands of the Lake Superior District', Sen. Doc., No. 69, Vol. I, p. 159; 1850.

which weight suggests that it was meant to be swung by two men. Near it was found the trunk of a small oak, the branches of which had been trimmed, leaving the stumps, so that it resembled the 'chicken-ladder' used by the Mexican miner to this day. The remains of baskets made of birch bark indicate the manner in which the broken rock was removed from these Indian workings, which involved no systematic mining, only the digging of shallow pits and trenches. In them have been found wooden shovels resembling canoe paddles.

We have no reason to believe that the Indians used the copper for other than ornamental purposes before Europeans entered their domains. The mass of copper found in the Minesota outcrop at a depth of 18 feet had been raised a few feet by means of logs. Hoy mentions a piece of black oak six inches in diameter cut from one of these logs, on which were found distinct marks of a narrow axe that must have been "very sharp".* Referring to other so-called ancient workings, he says that "the fresh condition of the woodwork, skids, and ladders, and the evidences that sharp axes were used in fitting the timbers is evidence that they are not of great antiquity". Jackson, in 1844, said that the work was done by French half-breeds and the Chippewas employed by them. The evidence of trees, believed to be aged, growing in the old diggings, has been misinterpreted. In the rubbish, for example, that covered the Minesota mass of copper to a depth of 12 feet, there was growing a hemlock tree that had 280 rings, but it must be remembered that the French penetrated into the Lake Superior region 300 years ago, a time fully sufficient to account for the seeming age of any of the diggings that have been discovered. In due course the European trappers made use of the copper for industrial purposes, thereby setting an example that the aborigines followed, in fabricating implements of peace and war. Satterlee Clark, an Indian agent stationed with the Winnebago tribe, said in 1828: "When I

* P. R. Hoy, *Trans.* Wisconsin Academy of Sciences, Vol. VI, p. 101; 1885.

first came among the Winnebagoes, many of them had copper-headed weapons. Many of them carried lances headed with copper. Masses of virgin copper were often scattered about, but particularly in the sand upon the beach of the Wisconsin. This was so pure and soft that it was no trouble to shape it to suit them".*

The Lake Superior copper, we are told by the Jesuit fathers, was carried far in the course of intertribal trade, but it had been borne southward also long before in the Glacial drift, and had become distributed not only in Wisconsin, but in the lower Mississippi valley. Moorehead, when exploring in Wisconsin, in 1902, expressed his surprise at the amount of copper he found on the surface between Two Rivers and Princeton, a hundred miles apart. He obtained 138 pounds of specimens of small size, "some of which", he adds, "have been partly worked by man".† In the burial mounds of pre-Columbian days have been unearthed implements and ornaments of hammered copper. Some of this contains bits of silver, proving thereby that the metal had been neither melted nor smelted, but that probably it was derived from the Lake Superior deposits, in which native silver and native copper are found in close association. In the mounds of the Turner group, in Ohio, there have been found "several nuggets of native copper, others partly flattened by hammering, and several hammered into sheets of varying thickness".‡ These sheets were divided into strips and then were cut into small pieces that were rolled into beads.

The marks of smoke and the finding of ashes close to some of the masses of copper in Michigan indicate that the adhering rock was loosened by the heat of wood fires, aided perhaps by splashing water upon the hot surface, to hasten disintegration. Such use of fire, characteristic of primitive mining everywhere, has been cited as an argument that the Indians must have discovered that the metal could be melted, but we must note

* *American Anthropologist*, Vol. I, p. 35; 1888.

† Warren K. Moorehead, *American Anthropologist*, Vol. V, p. 51; 1903.

‡ F. W. Putnam, *American Anthropologist*, Vol. V, p. 49; 1903.

that the high conductivity of the copper would render difficult, if not impossible, the fusion of any part of the mass under such conditions; and if by chance a small lump of copper in the rock adhering to the large mass was slightly fused, it is evident that the aborigines failed to recognize the fact, because all

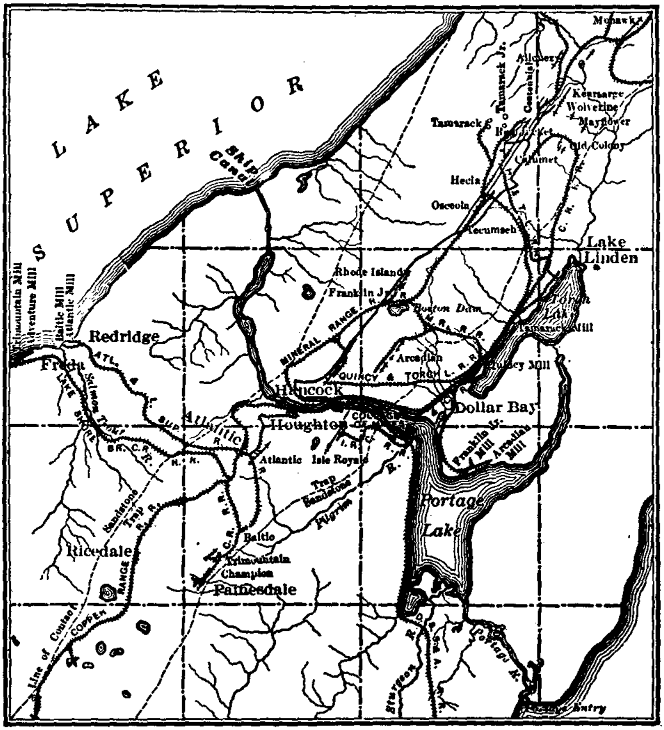


FIG. 18.—Lake Superior copper region.

their copper artifacts were shaped by hammering. The primitive mind works slowly; an effect would have to be produced many times before it would be noticed; and even then the reasoning from effect to cause might not be made. The Indians of the Lake Superior region, however, seem to

have appreciated the thermal conductivity of copper, for the explorers of the seventeenth century tell us that they cooked their food by heating the copper stones and putting them into water within a birch-bark pail. It has been remarked repeatedly by archaeologists that the altar fires of the Indians were hot enough to melt such copper ornaments as were placed beside them, and that therefore it is strange they should have failed to discover the fusibility of copper;* but this inference also is without metallurgic confirmation, because copper melts at 1083°C., whereas the slow burning of wood upon an altar, without any forced draught, would not subject anything placed near such a fire to a temperature in excess of about 500°C. Nevertheless, long before any Europeans came to America, the Indian mound-builders of the Mississippi valley, not knowing how to use heat to fuse their metal, learned to shape the native copper in the cold by placing a piece of approximate form in a stone mould and then hammering the soft metal to the required contour.† Experiment has shown that this can be done.

Mention may be made of the fact that at first it was thought, even by competent observers, such as Schoolcraft,‡ that these masses of native copper in the Lake Superior region were of volcanic origin, because they were rounded, by erosion.

Now we return to the enterprising Alexander Henry. He was prompted by what he had seen of the copper in the Lake Superior region to engage in mining, for, like the Jesuit father previously quoted, he concluded that the copper on the surface was but the outward and visible sign of hidden metallic wealth underground. In the spring of 1768 he made the acquaintance of Alexander Baxter, who had come from England for the express purpose of investigating these copper resources;

* Marquis de Nadaillac, 'L'Amérique Préhistorique', p. 181; 1885.

† George B. Phillips, *Journal*, Institute of Metals, Vol. XXXVI, p. 103; 1927.

‡ Henry R. Schoolcraft, 'Exploring Expedition to the Sources of the Mississippi River', p. 365; 1855.

whereupon the two Alexanders joined forces in founding the first mining company to operate in those parts. They started some men to digging for the native copper "imbedded in stone" in 1771, but after sundry misadventures, including the caving of the workings, they abandoned their attempt three years later. Even that brief experience had demonstrated that the difficulty of procuring workmen, the cost of transporting supplies, and the delay in reaching the distant metal market were adverse factors too serious to be overcome at that time. Moreover, we must note the fact that Alexander Henry himself, writing in 1776, avowed that his company was not organized to mine the copper deposits but "with a view to the silver, which it was hoped the ores, whether of copper or lead, might in sufficient quantity contain".* He added the remark: "The copper ores of Lake Superior can never be profitably sought for but for local consumption. The country must be cultivated and peopled before they can deserve notice". He was depressed by the high freightage to Montreal.

Then came an interval of inaction, until Douglass Houghton, an able scientist and a far-sighted man, drew attention to the copper deposits. In 1830 he made his first visit to the southern shore of Lake Superior in company with General Lewis Cass, who did not share his optimism; but, despite lack of encouragement, Houghton persisted in his purpose, although, curious to relate, he regarded the metallic condition of the copper as unfavorable to persistence of the ore in depth, and he held this opinion until he ascertained that the contrary "was more or less universal with respect to all the veins". The Calumet & Hecla mine is now 5720 feet deep, so these qualms were unnecessary, although fully warranted by previous experience in copper-mining, for native copper in the outcrops of veins is usually the product of weathering and of such decomposition as is due to oxidizing waters at or near the surface. Houghton was the mayor of Detroit and a citizen of wide influence,

* Alexander Henry, 'Travels and Adventures in Canada', edited by James Bain, p. 226; 1901.

yet he had much difficulty in persuading the legislature of Michigan to grant a small appropriation for the survey of the Upper Peninsula. He was appointed State Geologist in 1837 and forthwith gathered about him a capable staff, with whom he plunged into the wilderness and began a topographic survey.* He blazed the trail for the many able geologists that have followed him in unraveling the geologic structure of the copper country. Houghton's first report was printed in 1841, and aroused immediate interest; his report, clear and concise, told the world for the first time in convincing language that there were vast resources of copper upon the southern shore of Lake Superior, which at that time, it must be remembered, was as remote as Cape Nome is to us today. In 1843 an arrangement was made whereby he was enabled to combine a linear survey for the Federal Government with the geological survey he was making for the State of Michigan. This was necessary before mining locations could be recognized by the Federal authorities, and, moreover, some settlement had to be made with the Chippewa Indians, who occupied the region. This was done in 1843, when 30,000 square miles were ceded by the Indians, who were moved elsewhere, but without ever receiving full payment. The first mining permits were issued by the Government in 1844. In the following year Dr. Houghton's career came to a sudden and tragic end, when he was drowned by the capsizing of a sail-boat in which he was going across the lake to the Eagle River district.

The Government granted prospecting permits, or concessions, of nine square miles each, but this large area was shortly reduced to one square mile. A royalty of 20 per cent on the gross output was demanded, but as a rule it was not paid, the prospectors contenting themselves with searching for the lumps of copper to be found on the surface of the ground. In 1846, therefore, the permit system was dropped, and all mineral lands were placed on sale at the uniform price of \$5·00 per acre, this being reduced shortly afterward to \$1·25 per acre,

* T. A. Rickard, 'The Copper Mines of Lake Superior', p. 35; 1905.

the owners of registered claims being given the first chance to purchase any part of them they desired. From this time, 1846, the copper-mining industry of Lake Superior may be dated.* The growth of the industry is shown by the increasing output, in pounds of copper, in successive decades:

1845	24,880	1875	36,039,497
1855	5,809,334	1885	72,147,889
1865	14,358,592	1895	129,330,749

The first company to work in the Lake Superior region was the Pittsburg & Boston Company, which was organized in 1844 to operate the Cliff mine, in the Eagle River district, near Keweenaw point, at the northern extremity of the peninsula. The fissure veins in this locality had been described by Houghton and were first explored by Charles T. Jackson in 1844. The veins carried both native silver and native copper, not in layers of conglomerate or of amygdaloid, which proved to be the greatly productive lodes in later years, but in transverse fissures cutting across the bedded series of rocks. The Cliff mine was examined by Jackson and also by J. D. Whitney, both of whom in 1845 advised exploration through the foot of a cliff on the crest of which evidence of a copper deposit had been found. An adit was started at the base of this bluff, and at 70 feet it cut a lump of metallic copper, the first 'mass' (as such occurrences are termed) to be found by underground mining in the Lake Superior region. This discovery was important because it indicated that the erratic boulders of metal, previously found on the surface, had their origin in the lodes, and not in any foreign source.

The Cliff mine, from the start, was remarkably rich in 'mass' copper. Between 1846 and 1853 the sales of metal netted $1,328,406, from which dividends aggregating $462,000 were won. The depth attained was 462 feet. In 1870 work was discontinued, owing to impoverishment at the bottom level; up to that time the Cliff had paid its stockholders

* Horace J. Stevens, *The Copper Handbook*, p. 17; 1902.

$2,627,660 in dividends, or a little over twenty times the paid-up capital. In 1872 the mine was re-opened under a new management, and the output rose again, to 1,162,873 pounds of copper, in 1875; but after that the yield diminished, and in 1887 the operations ceased. In 1908 the Cliff was acquired by the Tamarack Mining Company.

The Minesota was discovered in 1847 by S. O. Knapp, who had noticed the surface indications of earlier diggings. In one of these, at a depth of 18 feet, he uncovered the mass of native copper to which reference has already been made. The first shipment from this mine was made in 1848, the year in which the first Minesota company was organized. The name is spelled thus, lacking an 'n', because the locator made the error. However, that was no handicap; up to the end of 1881 the dividends amounted to $1,920,000. Nearly 70 per cent of the product up to 1861 was in the form of 'mass', and only 6 per cent was 'stamp-rock', meaning ore that underwent treatment in a stamp-mill. This mill was a crude affair, and when the masses became scarce the company had to shut down, in 1890.

This mine will always be celebrated because it yielded the largest mass of copper ever found by aid of the miner's pick. In the Cliff mine, in 1875, a lump weighing 40 tons was found, and removed, but the Minesota surpassed this record with a mass of almost incredible size. Here I may say that it used to be said, 40 years ago, that in the Lake Superior mines there had been found masses of native copper so large that they could not be removed profitably. This myth has persisted to later days. So recently as 1901, an archaeologist* stated: "Our miners prefer those other forms [ores] and avoid the metallic copper, for it is yet impossible to blast it or otherwise detach the large pieces economically". Tell it to the marines! In 1857 a mass weighing 420 tons was found in the Minesota mine at a depth of 150 feet. The maximum length was 46 feet, the maximum width was 12½ feet, and the maximum thickness

* Harlan I. Smith, *Popular Science Monthly,* May, 1901, p. 110.

was $8\frac{1}{2}$ feet. The mean thickness was 4 feet. Twenty men labored for 15 months to remove this copper from its rocky encasement; and the work involved the use of both powder and chisels, as is told graphically by George D. Emerson, in 'The Mineral Statistics of Michigan' for the year 1880. First the miners excavated the rock next to the mass and exploded six kegs of powder. This proved unavailing, so further blasts with increasing quantities of powder, up to 30 kegs, were exploded. Altogether 110 kegs, or 2750 pounds of powder, were used before the mass was torn by the successive explosions. Incidentally we may note that the tenacity of the copper, a characteristic that baulked these miners, is a quality that made the copper valuable when it reached the surface. It was cut into small lumps by aid of chisels, which had a bit of $1\frac{5}{16}$ inch and were bevelled both ways; in length they varied, the general rule being to use a chisel 18 inches longer than the thickness of copper through which it had to cut. The hammer weighed 7 pounds, or $8\frac{1}{2}$ pounds including the handle.* The cost of cutting the metal was $12 per square foot, the resulting chips having a weight of 27 tons, which at the price obtainable for copper in 1857 was worth $8500, as against the cost of the labor of 20 men for 15 months, about $18,000. The 420 tons of crude metal and attached matrix would yield 75 per cent of refined copper, or 315 tons, which, at $400 per ton, net cash on delivery, after deducting cost of transport, conversion, and sale, would give $126,000, so that most assuredly it was a highly profitable find. Eighteen months were required to remove all of this huge mass of copper from the Minesota mine.

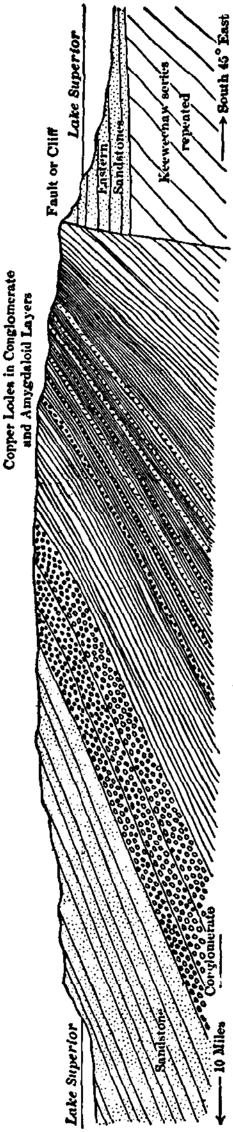
At first cape chisels with a $\frac{3}{4}$-inch bit, and later pneumatic cutters, were used to subdivide the masses of copper. One might suppose that the oxy-acetylene torch might serve the purpose, but the thermal conductivity of copper is an obstacle.

* Thomas Egleston, *Trans.* Amer. Inst. Min. and Met. Eng., Vol. VI, p. 287; 1879.

Nowadays the mass copper is cut by means of a high-speed twist-drill, from $11\frac{1}{4}$ to $26\frac{1}{4}$ inches long and of a gauge ranging from 1 to $1\frac{1}{16}$ inch. The foreman in charge marks the lines along which the piece is to be cut; then holes are drilled along these lines so as to leave only from a half to three-quarters of an inch of metal between them. Every seventh or eighth hole is drilled through the mass to determine its thickness, the other holes being stopped approximately one inch short of passing through the mass. The holes are filled with a powerful explosive, known as 90 per cent Rendite, from which the paper covering has been removed to assure the complete filling of each hole with the explosive material. A ridge of clay is then plastered along the line of holes and a train of dynamite known as 70 per cent Atlas A powder is laid along it, so as to connect all the holes by a continuous band of dynamite. A dynamite cap is placed in a stick of the Atlas A powder and all the dynamite is then covered with clay, after which the charge is exploded by means of an ordinary fuse. The violence and speed of the explosion expand the drill-holes, so that the desired piece of copper is ripped from the main mass. In practice it has been found convenient to limit the size of the pieces, to be detached and removed from the mine, to 5 feet in width, 10 feet in length, and a weight of 10 tons. A lump weighing as much as 14 tons was brought to surface from the Ahmeek mine in 1923. At the Ahmeek mine the cost of copper obtained from such masses is about the same per pound produced as of that which is obtained in ordinary stoping operations less the cost of milling. Mass copper can, and does, go direct to the smelter. It is interesting also to note that the production of such copper from the Lake Superior mines decreases in depth; in the Ahmeek mine the frequency and size of the masses, usually in sheet form, from less than an inch to fully twenty inches of pure copper, have decreased in a marked manner below 3500 feet on the dip of the lode. In recent years hardly any mass copper has been found in that mine, either in the fissure or in the main lode.

The occurrence of native copper has overshadowed that of native silver in the Lake Superior mines, but silver is a notable feature of the lodes. The largest piece of pure silver found in later years was in the Mass mine; it weighed 12 pounds. This piece formed part of the Michigan mineral exhibit at the St. Louis Exposition. In 1873 a small boy, while 'cobbing', or selecting bits of copper rock in the dump of the National mine, at Rockland, broke a piece of conglomerate in which was hidden a lump of 16 pounds of native silver. Captain J. C. Thomas informed the present writer that he had seen pieces of almost pure metallic silver weighing from 25 to 30 pounds in association with native copper in the Cliff mine. As much as $500 worth, he says, was extracted in a single night by the men, who presumably did not report the fact at the office. Many thousand dollars have been taken from the mines of Lake Superior in the form of silver secreted by the miners, not to mention the specimens that now enrich museums all over the world.

In 1854 the Central vein was discovered by John Slawson, the 'agent' of the Cliff company, who stumbled upon an old digging in which a large lump of copper was unearthed. This was sent to Detroit to be smelted. Three large masses were found in old workings, two of them overlapping; the total weight of metal was 53 tons. The thin edges of these masses had been hammered so that they were much bent, at which stage apparently the effort to break them had been abandoned. We need not assume that this was the work of any 'ancient' miners; in all probability it dates from the days of the French-Canadian pioneers. In 1865 the production of this mine exceeded a million pounds of copper, and in 1886 it rose to 2,512,886 pounds. In 1880 the output included 286 masses of copper, having an aggregate weight of 1,254,901 pounds. In 1895, at the thirty-first level, the vein was found to cease at a bed of conglomerate; its faulted extension is supposed to have been recognized, but it was barren of copper.



GREAT SUCCESSION OF DIABASE FLOWS WITH INTERBEDDED LAYERS OF CONGLOMERATE.

FIG. 19.—Geological section of Lake Superior region.

Prospectors soon picked their way southward from these Eagle River mines to Portage lake. The riches of the district now known as Calumet were unsuspected at first, and it was nearly twenty years before they were appreciated. The country around Portage lake was readily accessible by water and a settlement was made in 1847.* In that year the first of the bedded formations was uncovered, and the discovery led to the organization, in October 1848, of the Quincy Mining Company. The early exploration of this district, however, was not promising, for the simple reason that it was devoted chiefly to the fissures. For a year the Quincy company fussed over one of these worthless cross-veins, before the discovery of a rich bedded-lode formation was made by the Pewabic, a company organized by C. H. Palmer in 1848. Despite this encouragement the Portage district underwent no notable development for several years, the chief mines of the Lake Superior region being still in the Eagle River and Ontonagon districts. In 1852, however, the Isle Royale lode was found near the present site of Houghton and large quantities of native

* Graham Pope, Lake Superior Mining Institute, *Proc.*, Vol. VII, pp. 18–31.

copper were extracted with a success that made this mine famous, and, with it, the locality. The principal lode was a bed of amygdaloid, marked by a line of old pits for nearly a mile along the outcrop. Adjoining tracts of land were promptly taken up; and in 1853 the Huron Mining Company was organized at Boston, although the supposed extension of the Isle Royale lode was not traced into this ground until a year later. At this date Cornish miners began to arrive in large numbers, attracted by reports that had reached England. In 1854 and 1855 the mining industry of Portage lake was depressed; some of the companies, including the Quincy, had not yet found the lodes that subsequently proved so productive, and they were struggling along, engaged in mining either the poorer layers of amygdaloid, parallel to the rich lodes, or the thin veins, which cross them. In 1856 the Pewabic company found the great amygdaloid lode known by that name; and the neighboring company, the Quincy, quickly followed suit, at a time when hope and money were both at a low ebb. In 1873 the Quincy yielded 2,800,000 pounds of copper and in 1903 the output was 18,498,288 pounds.

The first copper-mining in the Lake Superior region, as we have seen, was based upon the veins of the Eagle River district; these cut across the bedding of the trap (amygdaloid) and conglomerate layers constituting the prevailing geologic formation. The early discoveries at this northern end of the Keweenaw peninsula were followed by mining in the lodes of 'mass' copper in the Ontonagon district, at the south end of the region, where the veins cut the bedded series at an acute angle on the dip. Subsequently came the discovery of abundance of native copper in the amygdaloid layers, as in the Quincy. Finally, the uncovering of a copper-bearing bed of conglomerate marked the beginning of another momentous development. Such was the discovery of the Calumet lode by Edwin J. Hulbert, John Hulbert. and Amos H. Scott in September, 1864.

The story of the Calumet & Hecla does credit to the intelligent persistence of the discoverer, Edwin J. Hulbert, and to the shrewdness of his financial supporter, Quincy A. Shaw, but it is marred by one of those not infrequent quarrels between men of unlike temperaments, resulting in the familiar dispute as to whether the man that finds the mine or the man that founds the great enterprise should be the chief beneficiary. Hulbert was a surveyor; he had laid out roads, mapped lands, and charted mine-workings for ten years before the discovery.*

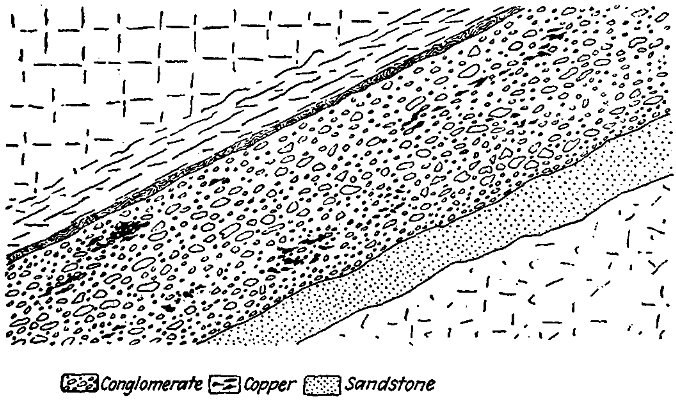


FIG. 20.—Section of a conglomerate lode.

He has related how, in 1853, he lived in the Eagle River district and became a keen student of mining geology under such veterans as W. H. Stevens, Samuel W. Hill, and Charles Whittlesey. At that time the mining of copper was restricted to transverse veins, the beds of conglomerate being disregarded. In 1858 he began a survey for a State road from Copper Harbor to Ontonagon, and in the course of this work he noticed a violent deflection of the magnetic needle on Section 23; this put him on the alert for a mineral discovery later. While making the northern part of his survey, he found fragments of a brecciated conglomerate containing native copper,

* T. A. Rickard, 'The Copper Mines of Lake Superior', p. 42; 1905.

similar to some 'float' that he had found several years earlier on the banks of the Eagle river. The conglomerate differed from all others in the district in being brecciated; and it was this fact that started him on his long and persistent search. In 1860, when making a final survey for the road from the Cliff mine to Portage lake, he picked up some fragments of the conglomerate, and shortly afterward he discovered a big block of it covered with moss; also, in the vicinity, he observed a depression that looked like an 'ancient' pit, similar to others that were known on the Keweenaw peninsula. He ascertained that this was on Government land, whereupon he bought 1920 acres, for the purpose of further exploration. The disturbed condition of business during the Civil War prevented him from doing anything until 1864, when the Hulbert Mining Company was organized with 20,000 shares, of which he held 5000, the remainder belonging to his associates, J. W. Clark, Horatio Bigelow, and other Boston men.

Hulbert discovered the Calumet conglomerate in a pit that he sunk on Section 13, at a depth of eight feet, under soil and drift. In the 'ancient' pit, the conglomerate was found by sinking below the bottom of the abandoned digging, which proved to be the work of the Indians, who had used it as a *cache*, or hiding-place, for copper that they had gathered elsewhere, on the surface. This *cache* contained the birch-bark baskets used for carrying copper, together with tanned deerskin, such as the Indians used for repairing mocassins. Moreover, 50 barrels of copper carbonate were taken out of the excavation, this being the weathered remains of the copper that had been secreted there long before.

Then, also in 1864, another company was organized by Hulbert and his Boston friends to acquire the land of Section 13, owned by the original company. This new company was named the Calumet Mining Company of Michigan. In the same month the Hecla Mining Company was formed with an equal capitalization, namely, 20,000 shares of the par value of $1, to acquire the larger part of Section 23. In the spring

of 1865 Hulbert went to Boston and arranged with Shaw for a loan of $16,800 wherewith to buy additional land. It was evident that the lode extended southwestward into Section 23; therefore Hulbert arranged with Shaw to purchase it from the St. Mary's Canal Mineral Land Company for the benefit of the Hecla company, with the result that Hulbert held one-third of the Hecla shares and Shaw, with his brother, the other two-thirds.

In 1866 the Calumet shares rose to $75, from their original $1 valuation. Nevertheless, successive assessments amounting to $12·50 had to be levied owing to the lack of mass copper in the lode and the difficulty of treating the ore. Many local stockholders sold their holdings, to their lifelong regret. What with assessments and loans, about $1,200,000 was required before the mine became a profitable undertaking, all the original promoters being severely tried in their efforts to provide money to develop the mine. During these vicissitudes Hulbert lost a part of his interest by having to exchange it for debt certificates of the Huron mine, of which he was manager. This embittered him, naturally enough; there ensued a quarrel with Shaw and the Boston directors; but eventually, in 1884, a settlement was made whereby Hulbert received $300,000 in Calumet & Hecla stock, which was placed in trust. The income from this supported him comfortably during the rest of his life, much of which was spent in Italy.

The Hecla paid its first dividend in 1869, and the Calumet in 1870. In the following year the two companies were consolidated with a capital of $2,000,000 in 80,000 shares. At that time the dividends of the united enterprises had already amounted to $1,850,000. In 1874, the output was 238,709 tons, yielding 4·22 per cent of copper at a cost of $8·48 per ton. In 1879 the capital was increased to $2,500,000 in 100,000 shares of $25, this being the maximum permissible under the laws of Michigan. The dividends in that year amounted to $1,600,000. At the end of 1882 the Calumet & Hecla had taken copper valued at $71,219,610 out of ground equivalent to

120 acres. In 1883 the average width of stope was reported as 8 feet, with a maximum of 20 feet, and an average yield of 4·5 per cent of copper. In 1923 a consolidation was effected between the Calumet & Hecla Mining Company, the Osceola Consolidated Mining Company, the Allouez Mining Company, the Centennial Copper Company, and the Ahmeek Mining Company, the newly formed corporation being named the Calumet & Hecla Consolidated Copper Company. In 1929 this consolidated company produced 90,319,000 pounds of copper, valued at $15,977,431 from its mines* at a cost of 11·43 cents per pound, and paid dividends amounting to $9,024,759. Up to the end of 1929 the consolidated company had produced 3,700,156,280 pounds of copper. During its long and successful life the mine has engaged the services of many notable men: the first president of the company was Alexander Agassiz, celebrated as a naturalist; he was succeeded by Quincy A. Shaw and later by his son, Rodolphe L. Agassiz. Among the engineers mention must be made of James MacNaughton, general manager from 1901 to 1926, at which time he became president, and C. Harry Benedict, metallurgist from 1898 to date. The Calumet & Hecla paid $184,027,028 in dividends up to March 31, 1930, of which $13,265,294 was received from the affiliated companies, so that from its own operations the Calumet & Hecla has paid $170,761,734.

The Tamarack enterprise owed its inception to Capt. John Daniell, who, when in charge of the Osceola mine, noted the regular dip of the Calumet conglomerate at an angle of 37½ degrees, and conceived the idea of intersecting the lode in depth beyond the western boundary of the Calumet & Hecla by means of a shaft that would have to be sunk 2260 feet vertically. After several years of planning he enlisted the financial support of A. S. Bigelow and Joseph W. Clark, of the Osceola directorate, who, with other friends, provided a quarter of a million dollars to buy the land and to commence the Tama-

* Also there were produced from the reclamation plants, at Lake Linden and Hubbell, 33,511,000 pounds at a cost of 5·62 cents per pound.

rack No. 1 shaft in 1882.* In those days such an enterprise demanded much money and courage, and Captain Daniell's idea was not well regarded, although subsequently, when it came to successful fruition, he received the credit due to him. The shaft cut the lode in 1885 at a point only 10 feet deeper than the Captain had calculated, and it was so rich in copper that the Tamarack became forthwith an important mine. When Daniell broke down in health, he was succeeded by his able lieutenant, Captain William E. Parnall, another redoubtable Cornishman. In 1900 the Tamarack produced 625,422 tons, yielding $3,299,077, of which $1,199,141 was profit, enabling dividends to the amount of $1,020,000 to be paid on the 60,000 shares of stock. Before being absorbed by the Calumet & Hecla, the Tamarack produced (1888–1917) 13,114,563 tons of ore, from which 378,650,348 pounds of copper were recovered.

The fact that the extension in depth of the lodes was not properly covered by claims in the direction of dip did not enter into the calculations of the early operators, but subsequently, when persistence in depth had been demonstrated by actual mining, this matter received attention. The Calumet & Hecla company, for example, undoubtedly made a mistake in failing to secure its deep-level ground, an omission that became the basis for the organization of the Tamarack company, whose first shaft was sunk vertically 2270 feet before it cut the Calumet conglomerate at a point 3780 feet from the surface as measured on the dip of the lode. The Calumet & Hecla group soon began to buy Tamarack stock on the open market and eventually in 1916 the Tamarack was absorbed by the Calumet & Hecla company, whose workings followed the lode to a distance of 9469 feet from the surface and to a vertical depth of 5720 feet, at which horizon the copper content is still such as to render possible profitable operations. The life of the enterprise has been prolonged usefully by the absorption of adjacent properties,

* Horace J. Stevens, *The Copper Handbook*, p. 258; 1902.

namely, those of the Osceola, Allouez, Centennial, and Ahmeek companies.

Most of the mines in the Lake district were developed from promising outcrops, but the Mohawk was found by the uprooting of a tree, caused by the falling of another tree that had been felled by a woodchopper. John Stanton, one of the honored worthies of the Lake Superior region, had already obtained an option on the ground with a view to prospecting. The chopper brought him a lump of rock showing native copper, which adhered to the roots of the tree, and Stanton then arranged for systematic exploration. A dozen pits were put down to a depth of 30 to 40 feet, and for lengths of 25 to 45 feet across the strike of the lode. All save two of these trenches exposed copper ore of good grade, and the evidence thus obtained was deemed sufficient to warrant the sinking of shafts. In this instance the drift overlying the true rock was only 12 to 20 feet thick; but elsewhere in the district such prospecting is rendered expensive by reason of a much heavier overburden of drift. On the Globe ground just south of the Champion mine, for example, there is as much as 200 feet of this 'wash'; and, in order to determine the position and character of a probable lode, it was necessary to put down two diamond-drill holes from a position some distance on the dip side, so as to intersect the lode at right angles, and these holes passed through 225 feet of drift and 600 feet of rock before they cut into the ore.

A good example of the application of geologic knowledge to mining exploration is to be found in the story of the Champion mine. But first a brief explanation is necessary. The trap beds, that is, the layers of diabase interbedded with the sandstone and conglomerate of the Keweenaw series, are so nearly alike that identification of any particular member is usually impracticable, but occasionally some mineralogic characteristic will serve as a guide; thus the foot-wall of the Kearsarge amygdaloid is a bed of trap marked by large feldspars. L. L. Hubbard, formerly State Geologist, used

this fact to determine the position of the Kearsarge conglomerate, and he proved that it was a reliable indicator. It is also proper to state that the officers of the Michigan Geological Survey recognized the foot-wall of the Mohawk as being this same bed, before they knew that any openings had disclosed copper; and they made known this identification at once, although it was a long time before the correctness of the correlation was generally admitted in the district. Usually the amygdaloid layers are more susceptible to weathering than the compact trap encasing them, in consequence of which

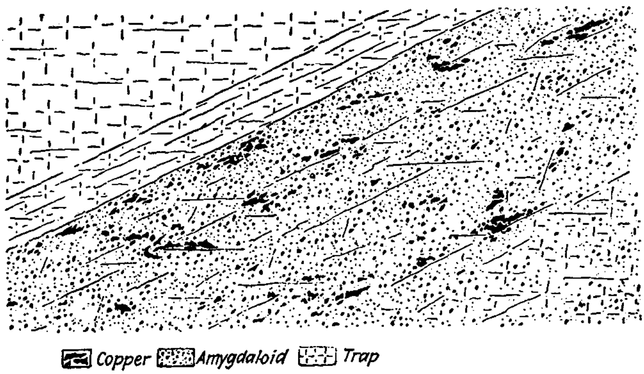


FIG. 21.—Section of an amygdaloid lode.

the softer rock becomes covered with debris and soil. The conglomerate beds, on the other hand, resist erosion and therefore show bold outcrops. It was by means of one of these that the Champion lode was discovered. In the Baltic mine, which exploited the Champion lode, there was a conglomerate bed 112 feet to the east, or in the foot-wall, of the copper-bearing Baltic-Champion lode. In his exploration over what became the Champion company's mining property, and over what was then a tract of bush-land belonging to the St. Mary's Canal Mineral Land Company, a solitary outcrop of conglomerate was noticed by Hubbard, and he took it to be the one above mentioned. The outcrop was

50 feet long, so that it gave a line of strike. Hubbard stepped 112 feet westward and came to a reef of trap, which was not what he was seeking; but a few feet beyond there was a depression in the surface; this was followed by a stream, in the bed of which he found some amygdaloid. By following the course of this amygdaloid, along another depression between two outcrops of trap, he soon unearthed some copper ore. Then, guided by the strike of the conglomerate, he followed the parallel amygdaloid; and when trenches were excavated, he found copper in all of them. This was the beginning of the Champion mine, of which the sagacious geologist above mentioned became the successful manager.

While in the district in 1904 I went to see some prospecting that was being done on another tract across which this same Baltic-Champion lode had been traced. Work was proceeding in an open-cut, recently enlarged from a trench, at the bottom of which a copper lode, amygdaloid containing native copper, was exposed. Fifteen inches of soil and gravel formed the surface layer, in which nests of carbonated copper were enclosed; these essentially were pieces of 'float', or detrital copper, so oxidized that the carbonated lump usually contained only a nucleus, as big as a pea, of copper coated with cuprite, which in turn was enclosed by melachonite and azurite. Under the superficial layer came 3 feet of 'hardpan', brecciated rock and gravel that was well cemented; and in this were to be seen more fragments of copper coated with cuprite and surrounded by the carbonate minerals; below this, within the cracks in the amygdaloidal rock, were copper stains for a further depth of 8 feet. At the bottom there was exposed a wide lode containing metallic copper distributed irregularly and to a degree not to be estimated by the eye.

Nature gave the Upper Peninsula a series of copper lodes. Man turned them to industrial use. The Lake region was explored and developed by men of many origins, and in their diversity they were representative of the composite human energy that conquered the American wilderness of

plain and forest, changing the desert to a granary and the waste to a habitation. Whoever desires to appreciate the causes that have stimulated the wonderful growth of these United States can, by going to Houghton and Calumet, observe two of the principal factors in that remarkable development, namely, the natural resources of a continent and the energetic men of many lands, competing in skill and united in effort. The roll-call of the inventors, engineers, and business men that have won distinction in the copper country indicates how many are the peoples that have partaken in this industrial conquest. The steam-stamp was the invention of Ball, a Massachusetts mechanic; the vanner is credited to William B. Frue, an Irishman, and his master mechanic, William Foster, of Fredonia, New York. August Heinback, a German, did much to develop the usefulness of the vanner; the jig was improved by John Collom, a Cornishman. The first iron-bodied jig was designed by S. E. Cleaves, from Maine. Another notable engineer was J. W. V. Rawlins, an Englishman. Philip Scheurmann, a pioneer millman, was a German. Bruno V. Nordberg, the designer of many of the large mechanical equipments, was a native of Finland. Alexander Agassiz was a Swiss. John Stanton, identified with sound practice and honorable dealing, was born in Somerset, England. James MacNaughton was born a Canadian. F. W. Denton is a son of New Jersey. E. D. Leavitt, another honored leader, was of Massachusetts; and if the roll of honor begins as it ends with the name of a New Englander it serves to suggest that little leaven which leaveneth the whole lump.

The men of mechanical ingenuity and administrative capacity exhibit great diversity of origin, but underground one race of men long continued to hold pre-eminence. The Cornishman is with honor save in his own country; there his obtuseness to the application of modern machinery has passed into a proverb; but outside the rock-ribbed peninsula of Cornwall, all over the world, he has taught men how to dig the ore. The story of the Lake mines is punctuated with

the names of 'captains' whose inherited instinct has piloted those that go down the mine in skips.

> By Tre, Pol, and Pen
> You may know the Cornishmen.

If the prefixes are not sufficiently indicative, you can trace them by the stories of their physical strength and good humor. They say that after Captain Martin Goldsworthy had been slanged by a dismissed workman, he was asked why he had not knocked the man down. With a vigorous aspirate, he replied: "That's one of the honors of the position". There was Captain William Parnall, who crossed the Atlantic when a boy of eighteen, being prompted to emigrate by a poaching escapade. He served in the water-works tunnel at Washington and became known as an expert hammerman. After two years in the coal and iron regions of the South, he came to Lake Superior in 1859. From worker in the National mine he soon became shift-boss, and then assistant captain. The superintendents of the mines in the Lake district were called 'captains', in Cornish fashion. Parnall became celebrated locally as a wrestler, particularly in consequence of a fight in which he vanquished a notorious bully. This episode attracted the attention of Captain John Chynoweth, who advised him to improve his natural abilities by study. He used to read at night, lying in his bunk with his miner's candle stuck in his hard hat—and that after an exacting day's labor. From being captain at the Franklin mine, in 1869, he advanced to posts of greater responsibility, and in 1890 he was appointed assistant superintendent of the Tamarack. He died chief at that mine in 1903. Two of his sons were graduated with the first class of the Michigan College of Mines, in 1888. Richard Uren and John Uren likewise were Cornishmen whom change did not stagger; they were willing to move with the procession, and sometimes to lead it. Captain Richard Uren possessed a good deal of mechanical ingenuity and busied himself with improving the devices used around the mine. He, like most of his countrymen,

traveled to different districts, and widened his experience; as superintendent of the Old Abe mine in the Black Hills, he became familiar with gold-mining in South Dakota; later, he was one of the first to open up the Wolverine; and there is no reason to doubt that if his ideas had been followed the Wolverine would have become a big mine many years before John Stanton actually brought it to that stage. Capt. John Daniell as we have seen, was the originator of the Tamarack 'deep-level'; and simple as it seems today to sink a shaft 2300 feet to cut the Calumet lode, it was a bold venture in 1882. Another good service he did was in advising Albert S. Bigelow to interest himself in the Boston & Montana group of mines, at Butte. Daniell was a good man underground, and had that sound judgment which is priceless; he was the captain that made the Osceola a profitable mine, after others had failed; and although not a technical man, he gladly availed himself of technical science. Captain Samuel B. Harris, Captain Johnson Vivian, Captain John Dennis, and Captain Thomas Hosking all did credit to the 'old county'.

It is a notable fact that in the first class sent out from the Michigan College of Mines, there were five sons of Cornish mine captains out of the seven that were graduated. The day of the old Cornishman has gone; his place has been taken by sons that are native Americans; and these, although better educated, lack the distinctive character of their fathers, having lost some qualities and gained others more adapted to their environment. Nevertheless, when technically educated men, American, whatever their fathers were, had the management of the mines, in 1904, I found the underground work still in charge of a Cornishman in every mine that I visited. Shoved aside at the surface in the march of technical advancement, the Cousin Jack still held his own underground, simply because he knew better than anyone how to break rock, how to timber bad ground, and how to make the other fellow shovel it, tram it, and hoist it. The old Cornish saying, 'A good bal makes a good cap'n', is still true; in the end the spark-plug of the mine mechanism is the shift-boss.

CHAPTER XI

THE EXPLORATION OF THE SOUTHWEST

The early Spanish adventurers found but little gold or silver on the American mainland, and the aborigines in the country that is now the United States were not as submissive as those of the West Indies, so the *conquistadores* obtained no foothold north of the Caribbean sea. Their later exploration northward had Mexico as a base—and wild yarns as a basis. The friar Marcos, a member of Estevanico's unfortunate expedition, brought the story of the Seven Cities of Cibola to Mexico City in 1539. Except as Indian hovels,* they existed only in a disordered imagination, but when Vásquez de Coronado's expedition pricked the glittering bubble, there appeared an enticing mirage in the northern desert: the glorious land of Quivira, where even the common pitchers and bowls were made of solid gold. Coronado proceeded northward and found only enormous herds of buffalo on the plains of Texas. It was a melancholy land. No gold or silver was to be seen among the poor Indians. Coronado reached the country of the Wichitas, in Kansas, before he abandoned his quest and turned home, which he reached, with only a third of his party, hungry and tattered, in 1542.

So long as greed stimulates the imagination there will be no lack of tales such as those that repeatedly led the Spaniards to the rainbow's end. In 1860 an expedition was organized in San Francisco by Dr. Darwin French to explore the desert country near Owens lake on the news that the Indians in those parts shot golden bullets.† The fact that the savages were known to possess few guns did not discredit the tale, which

* The Zuñi villages south of the present town of Gallup.

† W. A. Chalfant, 'The Story of Inyo', p. 86; 1922.

incited nine men to spend eleven months in the deserts of Inyo without finding any place in which gold was so common as to be used for ammunition, nor indeed did they find enough gold even for wedding rings, whereupon the deluded prospectors returned, as the Spaniards had often done, sadder, but not wiser, men.

Cabeza de Vaca records the fact that in 1536 when he was in the Davis mountains, east of the Rio Grande, the Indians gave to one of his companions, Andrés Dorantes, a large ornament made of copper on which a face was figured. He says it was *un cascabel gordo, grande, de cobre.** This has been translated by Buckingham Smith as 'hawks-bell'† and by Fanny Bandelier as 'rattle'.‡ One can not escape the literal translation of *cascabel* as 'hawk-bell', although it may have had a long handle that made it resemble a 'rattle'. The Indians from whom Dorantes received the object said that they had obtained it from their neighbors, and when these, in turn, were asked whence it had come, they said that it had been brought from the north, "where there was much copper, and it was highly prized". On crossing a mountain, "the stones of which were iron slags", probably lava, the Spaniards came to another Indian village, the people of which, when shown the copper bell, said that at the place from which it came there were a great many sheets of the same metal in the ground, and that it was highly valued. To this they added that at the place mentioned the people lived in fixed habitations.

Cabeza remarks that he and his companions thought that the copper country was on the South Sea, for they had always heard that it was richer in metal than the other sea, to the north. The Spaniards also believed that it had come from a foundry and had been made of cast copper. Both translators

* 'Naufragios y Commentarios', p. 109; 1922.

† 'The Narrative of Alvar Nuñez Cabeza De Vaca', translated by Buckingham Smith, p. 92, 1851.

‡ 'The Journey of Alvar Nuñez Cabeza de Vaca', translated by Fanny Bandelier, p. 139; 1905.

accept this inference, which is dubious to the point of incredibility. We have no reason to believe, and plenty of reasons for disbelieving, that the pre-Columbian Indians knew how to melt native copper, much less to smelt copper ores. The reference to the South Sea means the Pacific Ocean, and therefore westward. In that direction there was copper in the form of sheets or plates of native metal in at least two localities, Cananea and Santa Rita, in the regions that are now named Sonora and New Mexico, respectively. In the Veta Grande, one of the mines of the Cananea Mining Company, near the Mexican border, there occurs a soft white siliceous earth, close to a limestone and quartz-porphyry contact, in which sheets of native copper are found in a vertical position, so that they look as if they were "buried", which was what the Indians told Cabeza. And 90 miles north of Cananea is Santa Rita, where native copper in sheets and ragged lumps was obtained by the Mexicans long before any American miner started to work there. We may recall the fact that Castañeda, in his account of the Coronado expedition, in 1541, says that a chief in the Quivira country, probably Colorado, wore a copper plate upon his breast.* Such ornaments were worn by the Indian chiefs in Florida and in Alaska. They could even make a bell by hammering the copper into sheet form and then shaping it around a wooden core, which was the manner in which they fabricated various ornaments, such as ear-rings. There remains the possibility that the northern region from which the Indians said they obtained the copper may have been Lake Superior, but, although most of the copper of the aborigines in the Mississippi valley came from there, we need not look so far afield when the known copper deposits of the Southwest are so much nearer to the locality in which Dorantes was given the *cascabel de cobre.*

The first mention of real mining in the Southwest comes from Antonio de Espejo, a merchant of Mexico, who sought

* Pedro de Castañeda, 'The Journey of Coronado', translated by George P. Winship, p. 75; 1904.

northwest of the Rio Grande for a lake of gold of which there were rumors; that also vanished as he approached; but he is said to have discovered veins of rich golden ore in Arizona at a place now identified with Prescott. His report caused much excitement along the frontier.* Whereupon Juan de Oñate of Zacatecas organized an expedition for the purpose of establishing a settlement in the northern region known as New Mexico. Early in 1598 Oñate reached the sand dunes of El Paso. He went northward to Moqui, and from there he sent Marcos Farfán to the goldfield that Espejo had discovered, with orders to stake claims. But it all came to nothing; the distant mines could not be worked without Indian labor, and that could only be procured by exercising the force of a large military establishment. So New Mexico became a missionary field, with Santa Fé as the centre of a number of Jesuit outposts, until the Indians revolted, in 1680, and massacred such of the Spanish settlers as did not escape to El Paso.

The first information concerning the occurrence of copper in the Southwest was derived from the Indians, who, in the latter part of the eighteenth century, found native copper at Santa Rita,† now in the State of New Mexico. One account‡ says that this mine was acquired by the Mexicans from the Indians in 1780; another§ asserts that in the year 1800 an Indian, grateful for an act of kindness, showed the place to a Mexican officer, Colonel José Carrasco, and he, in turn, mentioned the discovery to his friend Don Francisco Manuel Elguea, a merchant of Chihuahua, who thereupon obtained a concession of the district from the Spanish government in Mexico. Elguea bought Carrasco's interest in 1804, and soon thereafter made a contract to supply the govern-

* Henry E. Bolton, 'The Spanish Borderlands', p. 169; 1921.

† T. A. Rickard, *Engineering and Mining Journal*, Vol. CXVI, p. 754; 1923.

‡ James O. Clifford, *Mining and Scientific Press*, Vol. CIV, p. 463; 1912.

§ Charles E. Chapman, 'The Founding of Spanish California', p. 28; 1919.

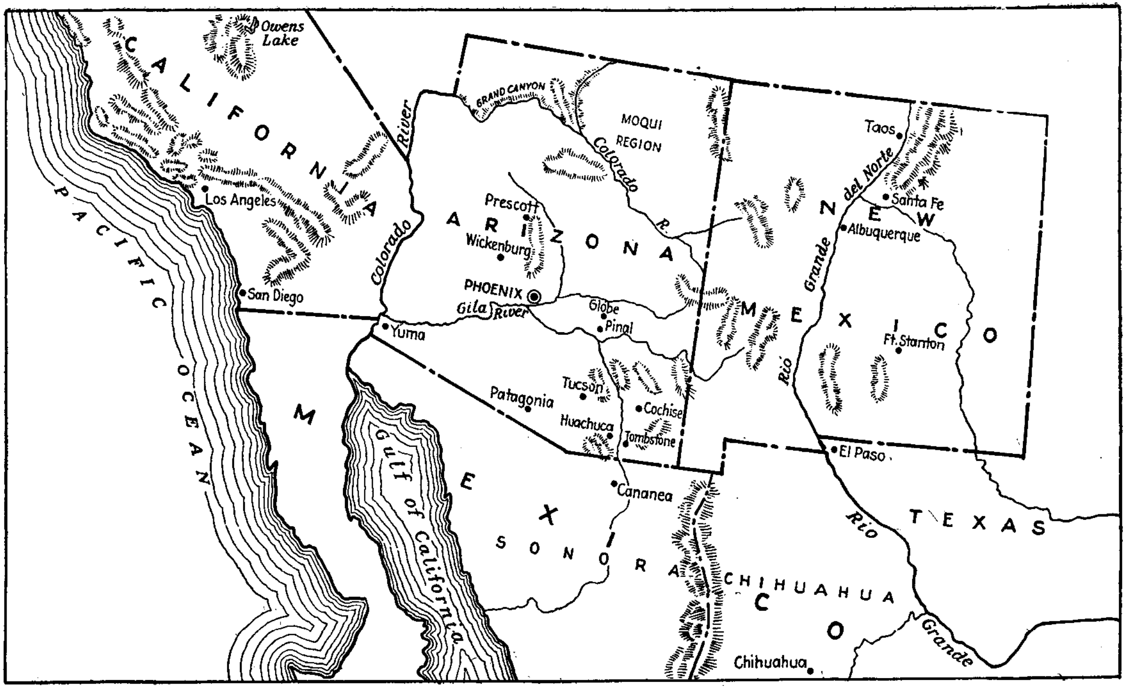


Fig. 22.—Map of the Southwest. (*Reproduction licensed—base material copyrighted by Rand McNally & Company.*)

ment with copper for coinage, the common copper coin being the *tlaco*, which was an eighth of the *real*, itself an eighth of the *peso* of today.

The native copper of Santa Rita is found in the form of small lumps scattered through the matrix of granodiorite, but more commonly the metal occurs in flakes, leaves, and tabular masses sometimes more than two feet square. The Indians, before the Spaniards came, are said to have hammered the copper into rude ornaments, as was done contemporaneously by the aborigines in other parts of North America. The mining of the Indians, the Mexicans, and the Americans up to 1882 was based mainly on the extraction of this native copper, and not of any other ore. To the Mexicans the deposit was a *criadero de cobre*, or place where copper was generated. The native metal stuck out of a big outcrop, and it is reported that masses weighing as much as a ton* were cut in pieces suitable for transport to Chihuahua.

Elguea made several visits to the mine. On the occasion of his second visit he built a triangular fort, with a martello tower of adobe at each corner, one of which survives. This fortification was meant to be a protection against the Apaches, and probably also to confine the convicts that had been loaned to him by the Mexican Government. Thus Elguea had the advantage of cheap labor; however, he was handicapped by the high cost of transport, on mules, over a rough trail for 300 miles. The ragged pieces of native copper were packed in wool, but even this made an awkward load, so a rudimentary furnace was built to melt the metal into ingots of 150 pounds, two of which made a fair load for a good mule. One of the old Mexican moulds for casting the copper has been found; it was cut in rock, and consisted of four recesses, 6 by 20 inches, side by side. Twenty ingots of copper were discovered in a clump of willows on Whitewater creek; these appear to have been dropped by persons in flight, probably at

* Arthur F. Wendt, *Trans.* Amer. Inst. Min. and Met. Eng., Vol. XV, p. 25; 1887.

the time when Santa Rita was evacuated hastily in fear of an Indian attack soon after the Mimbres massacre, a horrible episode in frontier history. In 1838 the State of Chihuahua had offered a bounty of 100 pesos on every Indian warrior's scalp, 50 for the scalp of a squaw, and 25 for that of a child. Sonora likewise was paying a bounty on Indian scalps, and allowed the captor to keep any booty he might seize. At this time a man named Johnson, a trapper, desirous of getting Apache scalps for the Chihuahuan government, invited the Indians to a friendly meeting on the Mimbres river, and when they were in the act of distributing some flour he had given them, he fired a howitzer loaded with slugs, nails, and bullets point-blank into them.* Is it strange that the Apaches retaliated? Such ugly facts as these must be kept in mind if we are to understand the hideous feud—not to be dignified by the word 'war'—between the white invaders and the red aborigines. Nor need we be surprised that during the centuries in which the Apaches resisted the invasion of their land, by Spaniards and Americans, the miner found it difficult and dangerous to establish his industry in the Southwest.

When Elguea died, in 1809, the Santa Rita copper mine was managed by Francisco Pablo de Lagera, by whom the property was leased to Sylvester Pattie, an American, in 1825. His son James Pattie shod his horse with the copper, which was hardly suited to the purpose, on account of its softness. Indian attacks stopped work at the mine. Next we find Coursier, a French resident of Chihuahua, in control at Santa Rita.† He is reported to have cleared half a million dollars in the course of seven years. Again the Indians hindered exploitation. A dispute also had arisen as to whether the mine was in Chihuahua or New Mexico. In 1848, by the terms of the treaty of Guadalupe Hidalgo, this part of the Southwest was ceded to the

* Thomas E. Farish, 'The History of Arizona', Vol. I, p. 116; 1915.

† A. Wislizenus, *American Journal of Science*, Vol. VI, p. 385; 1848.

United States, and two years later New Mexico was organized as a Territory.

Coursier was succeeded by Robert McKnight, who is said to have made a handsome profit out of the mine between 1826 and 1834.* Indian hostility again punctuated the history of the Santa Rita. In 1840 Leonardo Sesqueiro took hold and worked the mine for about fifteen years, when he had to abandon it, because the Indians cut him off from his supplies, which were brought from Chihuahua. Sweet and La Coste, both of San Antonio, Texas, were working the mine in 1860, when most of their workmen stampeded to the gold discoveries at Pinos Altos, which is 12 miles northwest of Santa Rita. Their operations also had suffered repeated interruption by reason of Indian raids. In 1862 Confederate troops, under General Sibley, invaded the region. They left a souvenir in the form of a mould for Minié balls that was found in 1910 when part of the old fort was demolished to make room for a machine-shop. La Coste and his associates resumed operations after the Civil War, and continued them until 1871, when the mine became involved in litigation, initiated by the Elguea heirs, who claimed the property under the terms of the old Spanish grant. This claim had not been settled in 1872 when a smelter-man from Colorado, named Matthew D. Hayes, endeavored to get title by applying for patent under United States law;† but the rights of the Elguea heirs were confirmed by both the Commissioner of Patents and the Secretary of the Interior. A few months later Hayes made a settlement with the Elguea heirs, and the ground was at once re-located by him under American law. In 1880 Hayes sold the mine to J. Parker Whitney, who, in 1898, leased it to the Hearst estate, which had large cattle holdings in this part of the country. Two years later a group identified with the Anaconda Copper Company obtained control, and Benjamin

* Rossiter W. Raymond, 'Mineral Resources West of the Rocky Mountains', p. 337; 1874.

† John M. Sully, 'New Mexico, the Land of Opportunity', p. 151; 1915.

B. Thayer was placed in charge, remaining at Santa Rita until 1903. Most of the mining was done by small parties of lessees, but some valuable orebodies were uncovered by company operations directed by Thayer. In 1906 an examination was made by John M. Sully, and it was on his report that this mining property was acquired by the Chino Mining Company in 1909.

Many are the tales that have been told in flamboyant pamphlets and books, intended to stimulate financial interest, concerning the rich mines in Arizona that the Jesuit fathers worked, and abandoned—for the benefit of later comers. The historic evidence available will not sustain this tradition. The Jesuits operated no mines, except, perhaps, on a small scale, some silver prospects near the Tubac presidio that were worked in later days, for example, by Charles D. Poston in 1856. Father Eusebio Kino is quoted by sundry writers* as testifying to the existence of rich mines in his day, but the description left by the *padre* does not apply to Arizona. In a letter written in 1710 the Jesuit father said: "In these new nations and new lands there are many good veins and mineral lands bearing gold and silver; and in the neighborhood and even in sight of these new missions and new conversions some very good new mining-camps of very rich silver ore are now being established".† This is part of a general statement, a benign and grateful survey of the blessings bestowed by a bountiful Providence, written by the good man when at the mission of *Neustra Señora de los Dolores*, Our Lady of the Sorrows. The mission was on the San Miguel river, in Pimeria Alta, in northern Mexico.

Raymond refers to early Spanish operations at Taos, in New Mexico, and says that they were stopped by the revolt of the Pueblo Indians, at which time the Jesuits, who were the principal miners and who used the Indians as slaves in their

* W. H. Robinson, 'The Story of Arizona', p. 283; 1919.

† Henry E. Bolton, 'Spanish Exploration in the Southwest', p. 458; 1925.

mines, were massacred.* He refers to the tradition concerning the productive mines that were worked before this expulsion of the Spaniards in 1680. It was said that the Indians, aware that the cupidity of the invaders had been the cause of their oppression, took pains to conceal the mines by filling them with debris so that in case their oppressors returned they would be unable to find them. This, said tradition, was done so effectively that when the country was re-occupied peacefully by the Spaniards, they were unable to find the mines. Therefore the Indians became credited with a knowledge of the places where these 'lost mines', fabulously rich, of course, were hidden. Raymond observes truly that in New Mexico, as elsewhere, tradition has wonderful tales to tell; thus, for example, at the mines of the Arroyo Hondo it is believed that a Mexican, named Vigil, found a document in an old church at Guadalajara, in Mexico, and that in this old document it was stated that the Spaniards had worked mines in the Taos mountains for silver, of which they obtained millions, so that at the time of the massacre in 1680 they had fourteen millions, whether ounces or pesos is not stated, all of which they hid in a shaft. A similar story is told of Gran Quivira, near Fort Stanton. To explain the failure to resume mining on the part of the returning Spaniards at the close of the seventeenth century, it was reported at Taos that the Indians expressly stipulated that they should not engage in mining but only in cultivating the soil. These stories are part of the historic background of the Southwest, in which such tales were accepted as gospel, and served, it is sad to relate, as bait to be used by clever promoters, who found the yarns useful when preparing a prospectus for the sale of stock in New York or Boston.

An incentive to the search for silver was given in 1736 by a remarkable discovery of large lumps of native silver at Arizonac, a locality in northern Sonora, just south of the present southern border of the State of Arizona. The discovery was made by a Yaqui Indian, who disclosed it to a

* Rossiter W. Raymond, 'Statistics of Mines and Mining', p. 397; 1870.

Mexican trader. A rush to the place ensued. No such masses of pure silver had ever before been seen at the surface. One lump of 2700 pounds and several others weighing from 200 to 400 pounds were found, besides numerous smaller nuggets. A decree of Philip V, dated May 28, 1741, states the weight of the balls, sheets, and other pieces of silver (*bolas, planchas, y otras piesas de plata*) to have amounted to 156 arrobas in all, or a little over two tons.* When the discovery was made known, Captain Juan Bautista de Anza, then stationed at Fronteras, came promptly to the place and laid claim to the find in behalf of the king of Spain. According to law, one-fifth of the silver would normally accrue to the King, but as this was a natural curiosity (*como cosa especial*) Anza decided that it should be sent to Madrid. If it did not pertain to the royal prerogative for this reason, then as a *criadero*, or growing-place, of silver, it would belong to the national treasury. The Viceroy (Linares) reversed Anza's decision, but the royal decree of 1741 sustained him.†

This notion that minerals and metals grow in an organic sense comes down to us from classic antiquity. Pliny makes several references to the idea, and Vannucio Biringuccio, in 1540, wrote an essay on 'The Generation of Metals', likening ore-bearing veins to the branches of a tree that are found in the mountains where "the minerals are ingendered". As an example, he cites the fact that "in some places of Hungarie at certain times of the year, pure gold springeth out of the earth in the likeness of small herbs, wreathed and twined like small stalks of hops, about the bigness of a pack thread and four fingers in length".‡ Please note the convincing details. In still later times, we learn, from Thomas Egleston,§ that in our

* Sylvester Mowry, 'Arizona and Sonora', p. 250; 1864.

† Charles E. Chapman, 'The Founding of Spanish California', p. 24; 1916.

‡ Richard Eden, 'The First Three English Books on America', 1540, edited by Edward Arber, p, 364; 1885.

§ Thomas Egleston, *Trans.* Amer. Inst. Min. and Met. Eng., Vol. IX, p. 638; 1881.

Southern States this myth prevailed; it was believed that the tailings of abandoned mines became so enriched as to be workable at a profit, the amount of gold thus obtained being proportioned to the interval of time elapsed, which meant the measure of the opportunity for the gold to grow. Many modern promoters appear to cherish this delusion; for, according to them, the resources of idle mines are magnified during a period of inaction.

In 1854 the locality of the Bolas de Plata was re-discovered by a party of twelve Americans, led by Charles Schuchard, who found a piece of silver weighing four ounces on the surface, and later they unearthed a lump weighing 19 pounds in some shallow old diggings overgrown with oaks.* This party of prospectors was driven away by the Mexicans, who claimed that the ground was within their territory, the boundary line of the Gadsden purchase (covering the part of Arizona that is south of the Gila river), made by the United States in 1854, not having as yet been fixed. The locality of the Bolas de Plata gave its name to the State, for it was known to the Spaniards as Arizonac, and when the party of Americans led by Schuchard and Blanding started work at Ajo, also in 1854, they called their company the Arizona Exploring and Mining Company. This is said to have influenced the choice of the name Arizona for the new Territory organized in 1863, although the Arizona Mountains proper are south of the Mexican line, in Sonora. Arizonac and Arizona are derived from the Moqui Indian words *ari*, meaning 'few', and *zoni*, 'fountains' or 'springs', the reference therefore being to the aridity of the region.†

These finds of native silver are interesting not only because they incited mineral exploration in the Southwest, but also because they suggest how primitive man, such as the Indians in Mexico and in Peru, found the silver that they turned into ornaments, merely by hammering, at a time when they did not know either how to melt metals or smelt ores. The native

* *Mining and Scientific Press*, Vol. XLVI, p. 126; 1883.

† H. H. Bancroft, 'History of Arizona and New Mexico', p. 400; 1889.

metal—gold, silver, and copper—was to them a soft and attractive stone.

The Spaniards coming north from Mexico made sundry mineral discoveries, as has been noted, but they were opposed persistently by the Indians. In 1751 a revolt of the Apaches against the Jesuit colony at Pimeria gave excuse for the later myth of an abandonment of profitable mines and smelters. The Indian revolts, such as those of 1680 and 1751, were important industrially because they meant a lack of peon labor. In 1767 the Jesuits were expelled by a decree of Carlos III. From 1790 onward, so long as the Apaches were quiet, some prospects were worked on a small scale by the Spaniards. Bancroft mentions several minor enterprises that were active during this period, among them .being gold placers on the Colorado river, quicksilver mines in the Moqui region, and silver mines in the Santa Rita mountains. In 1822 the Mexican revolution caused political disorganization, of which the Apaches availed themselves to commit numerous depredations, causing the mines to be abandoned. In 1841 the Texans invaded New Mexico, and in 1846 it became American territory.

The northern part of the present State of Arizona, that is, the territory north of the Gila river, was occupied by American troops in 1846, and the occupation was ratified at the conclusion of the Mexican war in 1848. Six years later, in 1854, the southern part of Arizona, south of the Gila, was acquired peaceably from Mexico under the terms of the Gadsden purchase, the sum of $10,000,000 being paid for it. Just before the Civil War a large amount of capital was drawn to Arizona for the purpose of working silver mines, but upon the withdrawal of Government troops, needed elsewhere, the Apaches and Mexicans raided the mining centres and brought operations to an end for the time being. Ross Browne in his report for 1863 bemoans the havoc that had been wrought by these incursions.

The population of the Southwest 70 years ago was decidedly disorderly, because, except for a few widely separated American

ranchers and miners, it was composed largely of outlaws. That fine old gentleman, Raphael Pumpelly, has told us, in conversation and in his book, of his experiences in Arizona during 1860 and 1861.* He says:

"There were refugees from the vengeance of the San Francisco Vigilance Committee, and from the States [which was the way in which people in our western Territories used to speak of the old parts of the United States], and there were escaped convicts from Australia. The labor element consisted of Mexicans, largely outlaws from Sonora. Back of them were the ever-present rarely visible Apaches."

It sounds like the scenario of a cinema performance at Hollywood. Pumpelly went as manager to the Santa Rita silver mines, near Tubac, which is 30 miles southwest of Tucson. He was the only one of five successive managers that was not killed either by Mexicans or by Indians. When this part of Arizona came into the possession of the United States it was almost depopulated save for the Indians. After the Gadsden purchase had been ratified, Colonel C. D. Poston entered the region at the head of an exploring party, which found some rich silver ore, and thereby attracted attention to the mineral resources of the Territory. Several mining companies were organized to develop mines, and a small American population, chiefly men from the Southern States and from the Pacific coast, was collected. Many of these were ruffians wanted by the police of Texas, Mexico, and California. Pumpelly describes the condition of the frontier communities:

"There was hardly a pretense at a civil organization; law was unknown, and the nearest court was several hundred miles distant in New Mexico. Indeed, every man took the law into his own hands, and a man's life depended on his own armed vigilance and prudence, and mainly on the fact that public opinion was the only code of laws, and a citizen's popularity the measure of his safety. In a society composed to a great extent of men guilty of murder and every other

* Raphael Pumpelly, 'My Reminiscences', Vol. I, p. 200; 1918.

crime, popularity was not likely to attach to the better class of citizens. The immediate result of the condition of public opinion was to blunt ideas of right and wrong in the minds of newcomers, who, suddenly freed from the restraints of the East [the Eastern States], soon learned to justify the taking of life on trifling pretexts, or even to destroy it for the sake of bravado. Murder was the order of the day; it was committed by Americans upon Americans, Mexicans, and Indians; by Mexicans upon Americans; and the hand of the Apache was, not without reason, against both of the intruding races."

Pumpelly recognized, as any fair-minded man would do, that the aborigines in Arizona, and elsewhere in our western territory, had ample justification for fighting the early trappers, prospectors, and settlers, however much he, and we, may sympathize with those that opened up the Great West and prepared the way for the well-ordered life we call civilization. The Apaches had no reason to be friendly to the Americans, any more than to the Mexicans, whom they had hated and fought for three centuries; they had been treated by the whites with the same cruelty that they themselves had practised in their savage methods of reprisal. When they were betrayed under cover of a white flag by an officer of the United States Government they could not be blamed for waging war ruthlessly. Pumpelly remarks that "the history of our Indian troubles through more than a century is the history of a people in the childhood stage of civilization, trying to maintain rights granted to them as wards by solemn government treaties—treaties that under collusion with a corrupt Department of the Interior have been continually violated by the 'Indian ring' and greedy hordes of land grabbers and swindling lawyers". Shall we say that it was an inevitable part of frontier life, which, manly and courageous, energetic and resourceful as it may be, is tinged with lawlessness, lack of scruple, and the direct methods of eager exploitation?

Throughout the early history of this part of the United States the belligerency of the Apaches was a hindrance to

mining. Incidentally, we may pause to recognize the fact that the land belonged to the Indians, that the Spaniards and other later adventurers from Europe were invaders, and that the refusal of the Indians either to submit to the foreigners or to surrender their patrimony is entirely to their credit. If they were cruel, so were the white men, whose treatment of them will not bear examination. The hostility between the prospectors and the Indians in the Owens Valley region, east of the Sierra Nevada in southern California, is typical of the long-drawn conflict between industrial exploitation and primitive savagery. A fair-minded chronicler speaks of "the pathetic resistance to the inevitable white domination",* and deplores the atrocities that were perpetrated by the frontiersmen in retaliation for Indian outrages. The outrage of the savage was synonymous with the atrocity of the white man, because the latter, nominally, at least, had a code that was higher than that of the primitive people with whom he was in conflict. The worst men, much worse than the most cruel combatants, were the white traders that sold guns to the Indians with full knowledge of the use to which they would be put. There were many such, to whom the desire of gain was paramount over any notion of elementary decency.

Theodore Roosevelt, a man keenly in sympathy with the spirit of the frontier, discussed this subject of the treatment of the Indians; he said:

"As for the whites themselves, they too have many and grievous sins against their red neighbors for which to answer. They cannot be severely blamed for trespassing upon what was called the Indian's land; for let sentimentalists say what they will, the man who puts the soil to use must of right dispossess the man who does not, or the world will come to a standstill; but for many of their deeds there can be no pardon. They utterly despised the red man; they held it no crime whatever to cheat him in trading, to rob him of his peltries or horses, to murder him if the fit seized them . . . Thus there are many

* W. A. Chalfant, 'The Story of Inyo', p. 120; 1922.

dark and bloody pages in the book of border warfare . . . Their deeds of terrible prowess are interspersed with deeds of the foulest and most wanton aggression, the darkest treachery, the most revolting cruelty; and though we meet with plenty of the rough, strong, coarse virtues, we see but little of such qualities as mercy for the fallen, the weak, and the helpless, or pity for a gallant and vanquished foe."*

A later writer states the case thus: "A handful of savages, knowing little of agriculture or manufacture or trade among themselves, having no conception of private ownership of land, possessing social ideals and standards of life based upon the chase could not and should not have remained unaltered at the expense of a higher form of life. The farmer must always have right of way against the hunter, and the trader against the pilferer, and law against self-help and private war".† This would be amusing if it were not pathetic in its smug prejudice. I ask the reader to imagine what would be the reply of an educated Indian, of whom there are many today, to this pitiful outburst.

The law of invasion was put into polite words by Captain A. T. Mahan at the beginning of the present century; he said: "The claim of an indigenous population to retain indefinitely control of territory depends not upon a natural [birth] right but upon . . . developing it in such a manner as to insure the natural right of the world at large that resources should not be left idle but be utilized for the general good".‡ This talk of 'natural rights' reminds one of the doctrines of Rousseau and of other quasi-philosophers. As to the exploitation of natural resources, one might put in a word for posterity, whose 'rights' are ignored by a too previous use of them.

This Indian question was one of the chief difficulties that the American prospector had to face, in Arizona and in other parts

* Theodore Roosevelt, 'The Winning of the West', part 1, pp. 121, 122, and 127; 1906.

† Frederick L. Paxson, 'The Last American Frontier', p. 15; 1918.

‡ A. T. Mahan, 'The Problem of Asia', p. 98; 1900.

of the West; it is a question that must not be ignored, although today the memory of it is blurred by romantic stories of heroic pathfinders and by blood-curdling tales of treacherous redskins. The Indians were robbed, cheated, and betrayed, repeatedly and continuously, until driven to retaliation in resentment and self-defence. At one time a million of them roamed over the continental area of North America, and under the nomadic conditions of a hunting life this was all the population the country could sustain, in contrast with the 123 millions that under well-organized industrial conditions are now able to maintain a high standard of economic welfare. The aborigines were bound to be dispossessed, it is true, but they might have been treated in a more humane fashion, and if they had been treated with some approach to fairness there need have been but little of the savagery that was shown alike by the Indian and the frontiersman. The failure to exercise good judgment in this matter delayed the development of our mineral resources, caused the loss of thousands of lives needlessly, and bespattered the pages of our frontier history with ugly patches that sadly disfigure its romantic features.

We, Americans, had plenty of sympathy for the Boers when they were vanquished by the British, without recognizing that the conditions that brought about that regrettable conflict had their parallel in the history of our own country. The Dutch and others that settled in the Transvaal were a pastoral people, and had no interest in mining. They themselves were intruders upon the domain of the natives, but that fact was ignored. When foreigners, *uitlanders*, found gold and diamonds, and thereby attracted a motley immigration of energetic exploiters of the mineral deposits, the Boer republic profited, in taxes and other revenue, but when the Boer settlers seemed likely to be overwhelmed by the alien population, they took steps that inevitably led to war. Roosevelt's argument, that the land belongs of right to him that knows how to beneficiate its resources, applies as much to the miners in the Transvaal as it does to the miners in Arizona. It is the

idea underlying the intrusion of Europeans among the backward peoples everywhere. We need not defend it; we may even regret it; but apparently it does make a difference whose ox is gored. As Bolton remarks, "the first battles for freedom in this land were fought by the red natives".

Despite Indian opposition, which obviously was legitimate, the prospectors in the Southwest persisted in going upon their lands to dig for ore. After the Civil War every military expedition was also a prospecting tour, because the soldiers were on the look-out for possible mines, but the reverse is also true, that every prospecting party had to be a military expedition, on account of probable attacks by the Apaches. The removal of the Indian menace greatly facilitated prospecting in the Southwest. It was not practicable to prospect and to watch the Indians at the same time: to hold a pick in one hand and a rifle in the other might be deemed heroic, but it was incompatible with profitable industry.

The silver-lead deposits of Patagonia, in the Santa Cruz mountains, 80 miles east of Tucson and only 10 miles north of the Mexican border, were discovered in 1858, on the hint of old workings, possibly of Mexican origin. The first locators were six officers of the United States Army, but they failed in their operations and sold the mine in 1859 to E. Brevoort, who, in turn, sold it to Lieutenant Sylvester Mowry, of the United States Army, in 1860. He had been in command of Fort Yuma. Mowry constructed twelve small blast-furnaces of Mexican type and produced silver-lead bullion, which he shipped to England. Some of this product he cupelled in Mexican *vasos*, to obtain the silver needed for current expenses, moulding it into bars of various sizes, ranging from $2 to $300 in value. These, he says, served as "a convenient circulating medium".* In 1862 Mowry was arrested by General Carleton, on suspicion of being a Southern sympathizer, but he was discharged six months later, an embittered and belligerent man.

* Sylvester Mowry, 'The Geography and Resources of Arizona and Sonora', p. 52; 1863.

In 1868 he obtained $40,000 damages from the Government, and went to London, where he died soon afterward. The mine, in the Harshaw district, was worked subsequently by the Standard Metals Company.

In May, 1860, a party of Californians led by Colonel Snively discovered gold in Rich gulch, near the site of Pinos Altos in the southwest corner of New Mexico. The news of the discovery brought a crowd of men to the locality, so that within six months there were 1500 on the spot. They worked the gravel in several gulches and averaged from $10 to $15 per day, which indicates highly profitable digging. In December the first quartz vein, the Pacific, was located by Thomas Mastin. In the spring of 1861 this prospect was bought by Virgil Mastin, a brother of the discoverer, who proceeded to work it energetically. Unfortunately the Apaches made several raids and seized the horses of the miners. On September 27, 1861, a band of Indians, 500 strong, was driven off after a severe fight, but Thomas Mastin, who commanded a company of volunteers, was killed, as well as several others. Depressed by this disaster, most of the miners left, but Virgil Mastin persisted in remaining. He could not do much however, on account of Indian depredations, until 1866, when he organized the Pinos Altos Mining Company, under charter from the territorial legislature of New Mexico. A mill of 15 stamps, each weighing 700 pounds, was erected, but it did not operate continuously, treating only about a thousand tons per annum for a yield of $35,000 during 1867 and 1868.

In January, 1862, a party led by Captain Powel Weaver discovered gold along the Colorado river.* While engaged in trapping fur-bearing animals, they stepped aside occasionally to prospect. They found gold in a gulch named El Arroyo de la Tenaja,† about seven miles east of La Paz, at that time a

* J. Ross Browne, 'Report on Mineral Resources', p. 454; 1868.

† Pumpelly gives an interesting description of these remarkable water-holes in granite. 'My Reminiscences', Vol. I, p. 256, and Vol. II, p. 774; 1918.

favorite shipping-point for merchandise going into the interior of Arizona. Captain Weaver kept the gold-dust that they gathered in a goose-quill, and when he went to Fort Yuma he exhibited it to his friends. Among those that heard of the discovery was Don José Redondo, who forthwith organized a small party and went to Weaver's camp, where he was shown the gulch in which the gold had been obtained. From this place the newcomers started to explore the district, and soon, within less than a mile south of Weaver's camp, Redondo, when engaged in panning, was astonished to get a *chispa*, or nugget, that weighed 2 ounces. Others of his party found good prospects in the vicinity, but as they had only come to reconnoitre, and were without either the necessary tools or provisions, they returned to La Laguna, a settlement about twenty miles above Fort Yuma, on the Arizonan side of the Colorado river. Shortly thereafter a party of 40 persons went to the placers reported by Redondo and soon after their arrival there, in February 1862, a number of fresh discoveries were made, indicating that gold was obtainable over a large area. Campo en Medio, Los Chollos, and La Plomosa were the Spanish names given to the rich diggings. When the news spread to Mexico and California there was a rush, so that soon 1500 men were at work. This number did not diminish until the spring of 1864, when the apparent exhaustion of the shallow placers and the extremely high price of provisions caused many to leave. Some of the diggers made money fast. Juan Ferrá found a nugget that weighed 47 ounces. Others found several *chispas*, as they called them, weighing from 20 to 27 ounces. It was said, boastfully, that not even a Papago Indian would work in these diggings for less than $10 per day. Lack of water was a hindrance, so that dry-washing machines were introduced, unsuccessfully. It is estimated that a million dollars was taken from these diggings in the first year. Later, several gold and silver veins were discovered between La Paz and Wickenburg, but most of the mines

were short-lived. Some copper mines, notably the Planet, near Williams Fork, proved more productive.

In 1863 Captain Weaver, a distinguished frontiersman, found gold south of Prescott and about the same time another famous pioneer, Joseph Walker, went into the country of the Pima Indians, along the Hassayampa, in central Arizona, and obtained gold in several places, notably in Lynx and Big Bug creeks, near Prescott, which soon became an important settlement, and eventually the capital of Arizona. One of the best of the mines opened up in 1863 was the Vulture, which was discovered by Henry Wickenburg, a member of the Weaver party. A pile of loose stones showing gold freely led to the discovery of a lode that was 15 feet wide. When the rush ensued the Apaches were attracted and many white men were killed while going from the waterless locality of the mine to the Hassayampa river, where they treated the ore in arrastras. The first of these was constructed for Wickenburg by Charles Genung in July, 1864.* When these grinding-mills were ready, Wickenburg arranged to sell his ore for $15 per ton, it being understood that the purchaser would mine and sort the ore himself, and transport it to the river. Two years afterward Wickenburg sold the mine for $75,000 to Benjamin Phelps of New York; he erected a 20-stamp mill at Wickenburg. Thomas Price, of San Francisco, has stated that the Vulture produced $2,500,000 from 118,000 tons of ore in six years. Later, an 80-stamp mill was built at the mine for the treatment of low-grade ore. The old stone buildings were torn down and crushed in the mill for a yield of $20 per ton. At a depth of 550 feet the lode was cut by a fault and the life of the mine was thereby abruptly terminated. An effort to find the lode beyond the fault is being made at the time of this writing.

General James H. Carleton encouraged mining when he was stationed in New Mexico during 1863. Many of his soldiers had mined in California and were keen to discover

* Richard E. Sloan, 'History of Arizona', Vol. I, p. 512.

gold while serving with him. The General sent a gold nugget to President Lincoln with the remark: "It will gratify him [the President] to know that Providence is blessing our country, though it chasteneth", the last reference being to the Civil War. He suggested further: "Would it not be wise for Congress to take early action in legislating for such a region, to open roads to give force to subjugate the Indians, to give mail facilities, to claim rights of seigniorage in the precious metals, which will help us to pay our debts?". This last again refers to the heavy expenses of the Civil War. Evidently General Carleton appreciated the mineral resources of the Southwest. He wrote from Santa Fé.*

The first prospecting in the Globe district was done by W. A. Holmes and a party of 30 men in 1869; when hard-pressed by the Apaches they fortified themselves near Cottonwood springs, and the remains of their fort are to be seen near the Bird mine. They were so harassed by the Indians that they had to move away. In 1873 the Adamson brothers found some good-looking outcrops and located several claims, but they were too far from any base of supplies; so they also departed. In 1875 a number of men came thither from Silver City, including Regan and Mason, who located the Globe claim, which later was developed successfully as a silver mine by Kayser and Simpson.

Several finds of silver on the surface are recorded. In 1871 General Carleton, then in command of the Federal troops in Arizona, established a post where the town of Pinal now stands. His successor, General Stoneman, constructed a road in 1873 that became known as the Stoneman grade. A soldier, named Sullivan, employed in building this road, when returning from work in the evening, sat down to rest on a boulder near the camp. Seeing some black pieces of rock, he picked them up, and, when trying to break them, he found that they "flattened out like a piece of lead", so says the

* James H. McClintock, 'Arizona', Vol. II, p. 403; 1916.

chronicler.* The soldier knew nothing about silver ore, but he put some of the pieces in his pocket and went his way to quarters. Shortly afterward his term of service expired, and he drifted to the ranch of Charles Mason, on the Gila river. Sullivan showed the black stuff to Mason and to others, but would not tell where he had found it. Suddenly one day he disappeared, and was never seen again. He was supposed to have been killed by the Apaches while trying to return to the place of his discovery. Whether the black stuff was native silver that had become blackened by oxidation or whether it was the black silver sulphide, argentite, it is not possible to say, because these two minerals have an equal hardness, which is slightly greater than that of lead.

In 1874 a party led by Mason was seeking for Sullivan's lost mine when they made the first location in the Globe district. Next year Mason and four others started from the Gila valley toward the Pinal range for the purpose of bringing some ore from the Globe mine. They traveled with a string of mules. On their way back they were attacked by the Apaches and one of them was killed. The survivors decided to carry their comrade's body to the old military camp, and in the evening they made a halt at the foot of the Stoneman grade. Next morning, when about to start, they ascertained that a mule was missing. One of the party, Isaac Copeland, went in search of it and found the mule standing on "a little brown hill", an outcrop. Going up to secure the animal, Copeland stumbled over some pieces of black rock, which was heavy and soft. It was Sullivan's find. Copeland rushed down the hill to his friends, shouting excitedly "I have struck it!". He showed pieces of the long-sought silver mineral. They located the Silver King claim on March 22, 1875. In 1881 when twenty stamps were pounding merrily on rich ore, there came a weary man, who went to the company's office, and humbly asked for work.

* Patrick Hamilton, 'The Resources of Arizona', p. 202; 1884.

It was Sullivan.* Up to 1884, the Silver King mine yielded $5,000,000. Much of this was native silver in leaf and wire form, in the ore. It is said that some of the silver was in crystalline clusters, and that before the reduction works were built, fully $1,000,000 was shipped to San Francisco as ore that assayed $1000 per ton.†

In Richmond basin also, on the western slope of the Apache mountains, were found nuggets of silver that attracted thousands to the Globe district in 1874. It is said that $100,000 in pure silver was picked up on the surface and just underneath. Several veins were disclosed in the search for this silver, and some of them were exploited subsequently, but without results at all commensurate with their promise.

The discovery of the Commonwealth lode, in Cochise county, is one of the romances of Arizona. A family named Pearce had a ranch on the outskirts of the Dragoon mountains; the two sons went occasionally to Tombstone to work as miners, but the ranch was not neglected, the principal asset being a small herd of cattle, which by care and thrift had increased, so that the time came when a carload could be shipped to Kansas City for sale. This was a great event. One of the sons, John, was entrusted with the shipment, which he sold in due course. On his return home, he found himself estranged from his family, for reasons too uncertain to be mentioned. This was in 1894. John Pearce left the ranch and went prospecting. He wandered over the Dragoon mountains and on a hillside where the desert lands approach the base of the mountains he found a big outcrop of quartz. This was a landmark; it had been known for many years, because it was on the line of the old trail through the South pass to Tombstone, but, apparently, it had never been tested. Travelers had used the lumps of quartz to make fireplaces, many of which were to be seen on the lee side of the outcrop.

* William P. Blake, *Engineering and Mining Journal*, Vol. XXXV, p. 238; 1883.

† Henry G. Ward, 'Mexico in 1827', Vol. I, p. 458; 1828.

Some of these pieces of quartz were rich in silver and gold, but Pearce made his discovery in the outcrop itself, from which he broke samples, intending to take them to Tombstone to be assayed. This was in February, 1895. His family was disinclined to provide any money for what was deemed a a wild venture, but his mother finally gave him the money needed to pay for the assays. They proved the ore to be rich; whereupon the whole Pearce family became interested in John's discovery; and John, forgiving former slights, was good enough to take the entire family, father and mother, two sisters, and brother, as partners in the mine. He regained favor in the domestic circle and everybody rejoiced. After a few carloads of rich ore had been hauled to the railroad and shipped to El Paso, the Pearce family began to think of selling the mine, for the sale of a mine, to people living in a mining region, is usually the simplest way of making quick money out of it.

At this time Richard A. F. Penrose, a distinguished geologist, whose home was in Philadelphia, happened to come to the district in company with John Brockman, an experienced mining-man of Los Angeles. The latter saw the mine first and asked Penrose to examine it. They arrived on horseback on December 24, 1895, and the next morning, Christmas day, they sampled the ore on the several claims that the Pearce family had located. The samples proved rich in gold and silver. The mine was purchased on May 1, 1896, and by August, 1899, the output had been 75,000 tons, yielding $4,000,000, of which $2,567,000 was profit.

Early in the summer of 1877 a small detachment of soldiers was marching from Wickenburg to Fort Huachuca; and with them went a prospector named Edward Schieffelin, who sought an opportunity to test sundry reports of rich ore to be found in the mountains southward. While the military party was passing through the San Pedro valley, Schieffelin packed his burros and went into the hills. He avoided any encounter with the Apaches and succeeded in finding some

good silver ore; then he returned to Globe, expecting to meet his brother, who, however, was not there; so he went to Signal, in Mohave county, where he found his brother, Alfred, and, on his suggestion, showed the 'float' he had brought to Richard Gird, then assayer at the Signal mill. Together the three men proceeded to the place of discovery, and located additional claims, which proved richer than the original location, the Tombstone. The others were named the Tough Nut, Goodenough, Lucky Cuss, and Grand Central. It is said that when Schieffelin was asked where he was going, he replied, "To look for stones"; whereupon the soldiers said, "The stone you'll find will be your tombstone", the allusion being to the deadly Apaches. Thus the district obtained its name. The discovery claim was recorded on September 3, 1877, which is the birthday of the Tombstone district.

Soon after the arrival of the Schieffelins and Gird, two other prospectors named Edward Williams and Jack Friday were looking for their mules, which had broken away from a dry camp and wandered along an Indian trail in search of water; the two men traced the mules by the marks of a chain that one of the mules was dragging; they noticed that in one place the rock surface had been so scratched as to disclose the gleam of metallic mineral; whereupon they started to dig. The claim they located was subsequently named the Contention, and it proved to be the richest in the Tombstone district. It was close to Schieffelin's claim. When Williams and Friday encountered him and his companions, it seemed that a quarrel over their locations would ensue, but the five men agreed to to divide the ground, the Schieffelins taking the lower end, the Contention, while Williams and his partner took the upper, the Grand Central. Soon afterward the Contention was bought by W. D. Dean, of San Francisco, for $10,000. In 1879 the Corbin brothers bought the Schieffelin interest in the Tough Nut for $1,000,000. Gird later received an equal sum for his interest. The Contention mine became highly profitable, but an increasing inflow of water into the workings

soon crippled the operations, as much as eight million gallons of water being pumped per 24 hours. In 1911 all work ceased.

It is interesting to note how frequently these early mineral discoveries were made by men either in uniform or associated with the soldiers serving in the Southwest, to check incursions of Southern troops during the Civil War or to curb the Apaches before and after that period. Many prospectors enlisted for the sake of the opportunity given them to see the country, so that militarism and mining became curiously associated. This may remind us that the word 'mine' had a military meaning long before it gained an industrial significance. A mine that is meant to blow up the enemy or a mine that is meant to destroy the enemy's ships is more in accord with the primary meaning of the word, the true derivation of which lingers in 'minatory', meaning threatening, for 'mine' comes from *minae*, a 'threat', and from *mina*, a 'point', or 'something that threatens'. The Romans learned how to demolish a barbarian fortification long before they acquired any technical skill in the art of working ores.

CHAPTER XII

COPPER-MINING IN ARIZONA

It is claimed that the first mining of copper by Americans in Arizona was done at Ajo, near the Mexican border, in 1854,* a year after this region had been added to the United States under the terms of the Gadsden purchase. A group of adventurers, organized at Los Angeles under the name of the Arizona Mining & Trading Company, came to the district. This party of prospectors consisted of 20 men, led by Major B. Allen, J. D. Wilson, and William Blanding.† They went first to Yuma, where the party divided, some of them going southward into Mexico while the remainder took the trail to Tinaja Alta, where they heard of the copper deposits of Ajo, which is 85 miles southeast from Yuma.‡ They found attractive outcrops of copper ore, and set to work energetically, but their operations suffered many interruptions, because that part of the country was still controlled by the Mexicans, who were uncertain about the exact position of the new international boundary. The Mexicans tried to expel them, but they held their ground. The first shipment of ore, consisting of native copper and cuprite, came from what is now the western end of of the New Cornelia workings; it was hauled in ox-carts to San Diego, 400 miles across the desert.§ Later shipments were hauled to Yuma and floated on barges down the Colorado river to the Gulf of California, whence the ore was loaded on

* Thomas E. Farish, 'The History of Arizona', Vol. I, p. 279; 1915.

† James H. McClintock, 'Arizona', Vol. I, p. 105; 1916.

‡ Courtenay De Kalb, *Mining and Scientific Press*, Vol. CXVI, p. 115; 1918.

§ Ira B. Joralemon, *Trans.* Amer. Inst. Min. and Met. Eng., Vol. XLIX, p. 593; 1914.

ships that carried it to Swansea, in South Wales, which was then the copper-smelting centre of the world.

The price of copper ores as delivered to the smelters at Swansea in 1866 is given by Ross Browne, as follows:

Ore containing 10 per cent of copper	\$33·87
Ore containing 17 per cent of copper	58·75
Ore containing 21 per cent of copper	67·62

The freight to Swansea from San Francisco was \$15, bags cost \$4 per ton of ore, and \$5 more per ton was deducted for commissions.*

It is worthy of note that camels were brought from Arabia for the purpose of carrying water from the Gila river to Ajo,† and some of these animals, when the use of them was discontinued, were seen occasionally years afterward in the desert lands of the Southwest like the wraiths of a forgotten fauna. Subsequently camels were employed in Nevada to bring salt to the mills on the Comstock, because the road to the salt deposits crossed sandy tracts over which mules and wagons could not be used. Later these camels also were discarded when salt deposits were found near Virginia City and in a locality that could be reached conveniently by more conventional carriers.

The mine at Ajo, known successively as the Cornelia and the New Cornelia, passed through the usual vicissitudes of fortune until in later days improved mining and metallurgical methods, preceded by diamond-drilling, created conditions favorable to the large-scale exploitation of comparatively low-grade ore. Several companies and several distinguished engineers failed to bring the enterprise to fruition until, in 1913, on the initiative of John C. Greenway, the Cornelia mine passed into the possession of the Calumet & Arizona Mining Company.‡

* J. Ross Browne, 'Mineral Resources of the United States', p. 208; 1868.

† Raphael Pumpelly, 'My Reminiscences', Vol. II, p. 768; 1918.

‡ T. A. Rickard, *Engineering and Mining Journal,* Vol. CXIX, p. 285; 1925.

Greenway, aided by Louis D. Ricketts, as consulting engineer, made a complete success of the venture. As the oxidized material had to be removed before the sulphide ore could be mined, they started a series of experiments in 1913 to determine whether such oxidized material could be beneficiated profitably by some simple leaching process. The tests were made by James Potter, assisted by Henry Tobelmann, as chemist. Later, a one-ton plant was started under the same direction. In the course of this experimental work several technicians, notably Stuart Croasdale, F. L. Antisell, Frederick Pope, A. W. Hahn, and W. H. Morse, were consulted. The composite result of their co-operative research assured favorable results, whereupon a 40-ton plant was erected and was operated for a year, followed by a plant of 5000-tons daily capacity, in 1917. This last proved completely successful. Two years later, in 1919, an experimental mill was built to test the treatment of the sulphide ore by flotation. Then came the erection of a flotation plant of 6000-tons capacity, designed by H. Kenyon Burch. This went to work in 1924. By recent remodeling this plant has been given a capacity of 20,000 tons daily. These large-scale operations would have been impracticable if an ample supply of water had not been obtained, by sinking a two-compartment shaft 650 feet deep at a place six miles distant, where the water-table of the region was tapped by four pumps, the total yield of 4550 gallons per minute being delivered to the reservoir at the mine against a frictional head of 1375 feet. Without an adequate supply of drinking water for the large force of men employed and without plenty of water for metallurgic purposes, the Cornelia enterprise would have been impossible. The finding, pumping, and distribution of this ample supply of water are not the least of the many engineering features that characterize this successful undertaking in the southwestern desert.

In July, 1917, the New Cornelia Company acquired the property of its neighbor, the Ajo Consolidated Company. This is another story. In 1912 Walter M. Briggs and James

P. Gaskill, aware of the successful treatment, by washing and leaching, of low-grade pyritic ore from the Rio Tinto mine, in Spain, at the plant of the Pennsylvania Salt Company at Greenwich Point, near Philadelphia, came to the conclusion that there was money to be made in the leaching of copper ores that could be mined cheaply with the steam-shovel.* The Ajo property was purchased by them, for James Phillips, from the Randall Ore Reduction Company, and diamond-drilling was started in 1913 by E. J. Longyear & Co., of Duluth, the contract price being at first \$2·50, and later \$2·25, per foot. In due course 11,000,000 tons of 2¼ per cent ore was proved. When the New Cornelia acquired the property the assured tonnage had increased to 21,000,000 of 1·55 per cent ore. The diamond-drilling on the consolidated property was continued until 71,000,000 tons of 1½ per cent ore had been proved. In November, 1918, the New Cornelia paid its first dividend. The production of copper from June, 1917, to April, 1924, was 247,869,655 pounds.

An incursion of Confederate raiders interrupted mining in the Southwest during the Civil War. In 1865, a regiment of Federal troops from California, under the command of Colonel J. H. Carleton, when in pursuit of Indians, became engaged in prospecting, which led to the discovery of Copper mountain, now known as the Clifton district, in Graham county, Arizona, but no claims were recorded. The first real mining was started by Isaac Stevens and a party of miners from Silver City, New Mexico, in 1870. They located several claims in Gold gulch, two miles west of Morenci.† Among the claims then recorded were the Yankee, Arizona Central, and Moctezuma. Work was commenced under American auspices, but with Mexican labor, in 1871, at the Longfellow mine. Robert Metcalf, who discovered the Longfellow, sold an interest in the claim to the Lazinski brothers, who had a store at Las Cruces, in

* T. A. Rickard, *Engineering and Mining Journal*, Vol. CXV, p. 9; 1923.

† James H. McClintock, 'Arizona', Vol. II, p. 421; 1916.

New Mexico. Shortly afterward all the original locators sold their holdings to the Lazinskis. An attempt at smelting the rich surficial ore was made in 1873 in a reverberatory furnace, with firebrick costing a dollar apiece.* This proved a failure, whereupon early in 1875 H. Lazinski erected a small Mexican adobe furnace, the blast for which came from a blacksmith's bellows. This furnace smelted only about one ton of ore daily, the loss of copper in the slag was excessive, and the consumption of fuel was enormous, not more than three pounds of ore being smelted per pound of charcoal, made from the mesquite on the surrounding hills.† An interesting series of experiments was then started by Lazinski and his brother. Commencing with a metal plate, sprayed with water, they developed a furnace constructed of copper troughs cast from the crude copper they were producing. By engaging in the sale of merchandise to the local community they diminished the cost of shipment, the horse-wagons that took the metal to the railroad, 700 miles distant, returning with supplies for their store. The first bars of copper cast in Arizona from the smelting of ore, as distinguished from the melting of native copper, were those carted from Clifton in 1875. They were produced by the Lazinski brothers from ore that came from the Longfellow mine.‡ These operations attracted attention to the district, and shortly afterward a group of claims adjacent to the Longfellow was acquired by the Detroit Copper Company, organized by Captain E. D. Ward, a steamboat-owner of Detroit. In 1882 the holdings of the Lazinski brothers were bought by a Scottish corporation, the Arizona Copper Company. During their control of the mine the Lazinskis are believed to have produced 20,000,000 pounds of copper, under great disadvantages, because the nearest railroad was at La

* James Douglas, *Trans.* Inst. Min. and Met., London, Vol. XXII, p. 532; 1913.

† Arthur F. Wendt, *Trans.* Amer. Inst. Min. and Met. Eng., Vol. XV, p. 43; 1887.

‡ James Douglas, *Mineral Industry*, 1897, p. 229.

Junta, in Colorado, 700 miles distant. Their supplies came from Silver City, New Mexico, and they built a wagon-road to expedite traffic. Charcoal for smelting was brought from the Burro mountains, 80 miles distant. A narrow-gauge railroad was built to Lordsburg, 70 miles distant on the Southern Pacific, in 1882. The extension of the Southern Pacific railroad did much to foster copper-mining in these parts, not only by facilitating the shipment of the metal to the New York market but by enabling the local smelters to obtain suitable mixtures of ores from the mines in Arizona itself. Until this could be done the winning of copper at Clifton and Globe, for example, despite the richness of their various siliceous ores, proved unprofitable.

William Church, an enterprising engineer from Colorado, who initiated the transactions that led to the formation of the Detroit Copper Mining Company, wished to build a smelter on the San Francisco river, six miles below the mine, and with that plan in mind he called on Phelps, Dodge & Company, in New York, offering them a half-interest in the enterprise if they would advance $30,000 for the building of the smelter. At that time James Douglas was about to come to Arizona to examine some mining claims for the Lewisohn brothers, who were feather-merchants in New York. Dr. Douglas was in charge of a small copper-reduction plant at Phoenixville, in Pennsylvania, and was known to Phelps, Dodge & Company, who thereupon asked him to investigate Church's proposal as well. He did so, and recommended the advance of the money, which participation marked the entry of Phelps, Dodge & Company into the Clifton district as half-owners of the Detroit property. This contact between Douglas and the Phelps-Dodge company was the beginning of a life-long association, profitable and honorable to both parties, and most fortunate for the mining industry of Arizona.

The chasing of Apaches, which long continued to be the favorite sport of American troops in the Southwest, led to several mineral discoveries on the part of observant soldiers.

One of them, a scout named Jack Dunn, in August, 1877, located a claim called the Rucker, near the Mexican border, thereby starting the copper-mining that made Bisbee famous. Dunn's location was named after J. A. Rucker, an army officer, to whom was given a share in the claim.* The Copper Queen deposit was discovered by Hugh Jones in 1877 and a claim named the Mercey was located by George Warren, after whom the district is named, on December 27, 1877. This claim was re-located as the Copper Queen by George H. Eddlemann and M. A. Herring on December 15, 1879. The original locator, Jones, abandoned his discovery because he saw nothing more than "copper-stained rock". A little copper-furnace was erected by Warner Buck on the Robb claim, owned by D. B. Rea, of Tucson, and some matte was produced unprofitably in 1878. The Copper Queen prospect was purchased by John Ballard and William Martin, of San Francisco. They were successful contractors, but entirely ignorant of mining; they had, however, the advice of two competent men, Ben Williams and Louis Williams, the sons of John Williams, of Globe. Under their direction, George Center built a smelting-furnace, a 36-inch water-jacketed cupola, in 1880. This little smelter treated an ore yielding 23 per cent of copper, and for a time did well. The fuel was English coke, brought by way of San Francisco.

In 1881 James Douglas came to Bisbee and obtained an option on the Atlanta claim, which was next to the Copper Queen. In developing the Atlanta, Dr. Douglas was unsuccessful at first in finding ore, and after he had spent $70,000 in exploratory work it was proposed by his associates to discontinue operations, but on his advice they agreed to advance $15,000 more for development, with the understanding that if this renewed attempt failed to discover sufficient ore, they would abandon the venture.† Sinking was resumed, and

* James H. McClintock, 'Arizona', Vol. II, p. 429; 1916. Also Patrick Hamilton, 'The Resources of Arizona', p. 166; 1884.

† James Douglas, *Trans.* Inst. Min. and Met., Vol. XXII, p. 534; 1913.

within a few feet the Atlanta workings penetrated a great orebody, which proved later to be the basis for a magnificent copper enterprise.

Meanwhile Ballard and Martin had exhausted the ore in the Copper Queen, and in 1884 litigation was threatened between them and the owners of the Atlanta, whereupon the two mines were joined in the name of the Copper Queen Consolidated Company. Ballard and Martin thought themselves smart in selling a mine that they believed to be exhausted, and were glad to dispose of it to the firm of Phelps, Dodge & Company, for whom Dr. Douglas was acting. That was in 1885. Douglas then became the moving spirit of this company and of other mining operations undertaken by the Phelps-Dodge company in Arizona. In 1890 he engaged Louis D. Ricketts as his assistant; this professional association continued for 17 years. In 1904 a geologic study of local conditions was made for the United States Geological Survey by F. L. Ransome.*

In due course the Copper Queen company extended its territory by acquiring the Goddard properties and by purchasing outlying claims, including the Neptune and Lowell groups. The Irish Mag and one or two other desirable claims, however, were involved in litigation because the owner, an Irishman named James Daley, was a fugitive from justice, and a Mexican wife became claimant to his belongings. Eventually the Supreme Court of the United States recognized her title, which soon afterward passed to Martin Costello of Tombstone. He was willing to sell for $500,000, and Douglas was willing to take a bond at that price provided he could explore the property by extending the underground workings of the Copper Queen mine, whereas Costello insisted that the work be done from the surface of the Irish Mag, so that he would have a shaft in case the deal fell through. When these negotiations failed, in 1901, the Irish Mag was purchased by a

* Frederick Leslie Ransome, 'The Geology and Deposits of the Bisbee Quadrangle', U. S. Geol. Survey; 1904.

group of gentlemen from Michigan and Pennsylvania in the name of the Lake Superior & Western Development Company, which later became the Calumet & Arizona Mining Co., the leaders of which were the Hoatson brothers, Thomas F. Cole, George E. Tener, Chester A. Congdon, and Charles Briggs. This company subsequently acquired additional territory and eventually became one of the leading producers of copper in the Southwest. Litigation over apex rights would have ensued between this company and the Copper Queen if Douglas had not possessed the sagacity to arrange with his neighbors to waive any extra-lateral rights in favor of the common law, whereby each company waived any claim to ore in depth that was vertically outside its side and end lines. At the same time an agreement was made giving each company free access, for information, to its neighbor's underground workings. This not only ensured peace but also the opportunity to become informed concerning discoveries of ore, all of which redounded greatly to the prosperity of the district, and, I may add, to the esteem in which Dr. Douglas was held by his fellow-engineers.

Only oxidized ores were worked by the Copper Queen company until 1893, when converters were added to the smelting-plant. As early as 1886 a film of matte floated on the bars of copper and the quality of the metal suffered so much that the direct method of smelting had to be abandoned, whereupon matte was made, and reduced in the converter. In 1906 the production was 71,711,813 pounds of fine copper, together with 332,311 ounces of silver and 7573 ounces of gold. In 1912 the output was 692,995 tons, containing 81,597,115 pounds of copper, 674,086 ounces of silver, and 13,863 ounces of gold. In addition to the copper ore, the mine yielded 10,626 tons of lead ore, containing 2,953,685 pounds of lead, 325,931 ounces of silver, and 3889 ounces of gold. From 1885 to 1930, inclusive, the Copper Queen mine yielded 29,166,780 tons of ore, from which there were extracted 2,740,752,125 pounds of copper, 99,158,282 pounds of lead, together with 20,451,071 ounces of silver and 486,690 ounces of gold.

Mining, not for native copper, but for the blue and green carbonates, to be used as pigments, was started by the Indians at Jerome, on the outcrop of the United Verde orebody, at a date that takes us back to Spanish dominion. The Verde (or green) valley was visited by Espejo in 1583. Antonio de Espejo, a wealthy citizen of Mexico, led an expedition into the country west of New Mexico, and when in the Verde valley he was told by the Indians about their mines, which were diggings on the mountain west of the river. "I found them", he says, "and with my own hands I extracted ore from them, said by those who know to be very rich and to contain much silver." Pérez de Luxán, who accompanied Espejo, had a different opinion; he wrote in his journal that the mines were in a very rough sierra and were worthless; the Spaniards, according to him, could find no trace of silver, "as they [the mines] were copper mines, and poor".* Later, Juan de Oñate, who became Governor of New Mexico, sent Captain Marcos Farfán in 1598 to find the mines reported by Espejo. He found a mine "at a good height" where there was "an old shaft, three *estados*† in depth, from which the Indians extracted the ores for their personal adornment and for the coloring of their blankets, because in this mine are brown [iron], black [manganese], water-colored [chrysocolla], blue [azurite], and green [malachite] ores. The blue is so blue that it is understood that some of it is enamel".‡ I have inserted the probable minerals used for the respective pigments. The Spaniards with Farfán had no knowledge of mining; yet they located a large number of claims and Oñate himself stated subsequently that these mountains were "without doubt the richest in all New Spain". On their

* 'Expedition into New Mexico made by Antonio de Espejo', Journal of Diego Pérez de Luxán, translated by George P. Hammond and Agapito Rey, p. 107; 1929.

† An *estado* is the height of a man.

‡ Henry E. Bolton, 'Spanish Exploration in the Southwest', p. 244; 1916.

return to San Juan Bautista in New Mexico, we learn of one assay of 11 ounces of silver per *quintal* (100 pounds). Farfán had no tools and his men obtained the samples by using their knives and daggers. This was characteristic of Spanish exploration; they searched for mines with the sword, not the pick. In their magniloquent way they named the Verde *El Río de los Reyes*, and described it as "a large and copious river". The valley and its hillslopes seemed to them most attractive; on the banks of the river flourished grapes, walnuts, flax, and blackberries. The Indians had fields of maize and were prosperous.

Espejo records his visit to the salt deposits near Camp Verde; these are being exploited today by a company known as Sodium Products, the principal commodity being sodium phosphate. The Indians obtained common salt here at a time when they were living in cliff grottoes; some of their stone hammers and stone picks have been found, together with a human skeleton, lying near remnants of sandals and a brush torch.*

The earliest settlement of Americans in the Verde valley dates from 1865, when a party of pioneers migrated thither from Prescott and chose a tract of land near the mouth of Clear creek. Two hundred acres of land were cleared and ditched, the principal crops being grain and vegetables. It is recorded that barley, threshed by hand, was hauled over the mountains to Fort Whipple, near Prescott, to be sold there for $17 per hundred pounds. The valley became widely known as an agricultural district and therefore attracted new settlers, so that in the succeeding 15 years most of the tillable area was occupied. At that time the covered wagon was the chief vehicle of transport.

Sixty years ago the valley and its enclosing hills had an appearance far different from what it has today. In summer the hills were covered with luxuriant grass, waist-high, in

* George J. Young, *Engineering and Mining Journal*, Vol. CXXIV, p. 18; 1927.

which game, chiefly deer and antelope, was plentiful. The bottom-lands were covered with forests of cottonwood and sycamore. The river was never in flood, because the grass on the hills retarded the run of the rain-water and the dams of the beaver served to check any sudden rise in the level of the river. The too intensive pasturage of cattle destroyed the grass, the miner demolished the trees, while the fume of the smelter poisoned both, so that today a district once verdant and productive has become notable chiefly for a scenery of the Syrian type, in which the high coloring is the result of aridity.

The life of the pioneers was made hazardous by the Yavapai Apaches, who, naturally, did not like to be dispossessed of the good land in the valley that had belonged to their people for generations. To protect the American settlers, a detail of soldiers was sent by the Federal Government in 1865, and a camp, named Fort Lincoln, was established near the Haskell ranch. This camp was occupied by regular troops in 1866, but five years later they were moved to Camp Verde, which in turn was abandoned in 1900, when all danger of Indian depredations had passed.

The first mining claim to be located in the Jerome district was that of Alfred Sieber, a noted scout, in 1877; he named it the Verde. Two more claims were located along the outcrop by John Dougherty and J. D. Boyd in the same year, and the Verde mining district was organized shortly afterward. In 1878 three adjoining claims were located by M. A. Ruffner and the two McKinnon brothers, John and Angus.* Their locations included the Eureka and Wade Hampton. These three men, in partnership, drove a short adit that connected with a 45-foot shaft. The showing of ore was encouraging, but it appears that the owners of the prospect were afraid to extend their workings deeper for fear they might knock the bottom out of the mine and thereby spoil the chance of a satisfactory sale. In 1882 a favorable mention of the mine

* James H. McClintock, 'Arizona', Vol. II, p. 406; 1916.

caused F. F. Thomas to come from Prescott for the purpose of an examination. He was an excellent engineer, of high character, as he proved during an honorable career, part of which was spent as manager of the Central mine at Broken Hill, Australia, and part as manager of the Gwin mine, in California. Thomas was so favorably impressed by the Verde mine that he persuaded F. A. Tritle, sometime Governor of the Territory of Arizona, to join him in the venture. The McKinnons were paid $500 in cash and were to receive $15,000 on December 1. Thomas took options on the adjoining claims, making eleven in all. They had good copper showings, and assays proved the ore to contain gold and silver as well. Thomas and Tritle then obtained the financial assistance of James A. Macdonald, president of the Queen Insurance Company, and of Eugene Jerome, both of New York. In 1883 the United Verde Copper Company was organized with Macdonald as president and Jerome as secretary-treasurer. To the latter came the honor of giving his name to the town, which, at one time, was the capital of Arizona and in later days has won worldwide fame in consequence of the two great mines in its vicinity.

Thomas was appointed superintendent. He built a 50-ton furnace and smelted the ore with moderate success, but the cost of shipping the products to a refinery was too burdensome. During the last five months of 1883 slightly more than 2,000,000 pounds of matte and black copper were produced at an operating cost of 7 cents per pound. This was derived from the rich oxidized ore found at or near the surface; it contained gold and silver, as well as copper. The black copper (known as 'bullion') was 94 per cent and the matte about 60 per cent copper. Both products were hauled to Ash Fork, on the Atlantic & Pacific railroad, which had been built into Arizona in 1882. Before that date the nearest railroad station was Abilene, in Kansas. The freightage from the mine to Ash Fork in 1883 was a cent per pound each way. The coke for the smelter was shipped from Wales to

San Francisco, and thence by rail to Prescott Junction. The cost of it is not known, but coke produced near Albuquerque, New Mexico, was quoted at $11 per ton, and by the time it was delivered at Jerome it cost $35 per ton. The smelter products were sent to the Orford refinery in New Jersey; the freightage, on a declared value of $300 per ton, was $51·38 from Ash Fork; this, when added to the local haulage, brought the total cost of transport, from smelter to refinery, to $71·38 per ton. At that time the price of copper was 14·5 cents per pound, and although the company was in debt, it seemed that its obligations would soon be liquidated and that handsome profits would accrue to the shareholders. Unfortunately the ore available was soon exhausted and no new orebodies of sufficient richness could be discovered; so the enterprise came to an untimely end, in 1887.

In 1888 William A. Clark, subsequently Senator from Montana, bought the United Verde property and started fresh exploratory work. He had known of the mine for many years; in 1884, he had been appointed commissioner to represent the State of Montana at the New Orleans exposition. Among the mineral exhibits he noticed some specimens of copper ore from the United Verde mine; these interested him because the assay-certificates attached to the specimens showed that gold and silver were associated with the copper.* In his customary methodical manner he made a note on the subject. When he returned to Montana, he forgot about it, but he was destined to be reminded of the United Verde two years later. Clark's mines at Butte, which were highly productive, supplied ore to the Port Orford Copper Company, in New Jersey. When this smelter went into liquidation, in 1886, he was one of the chief creditors. He assumed control of the refinery and operated it for a year or more. When examining the records he found assays of ore shipments from the mine in Arizona that had supplied the specimens he had noticed at New Orleans. Thereupon, in 1888, he sent

* T. A. Rickard, *Mining and Scientific Press*, Vol. CXVI, p. 9; 1918.

Joseph L. Giroux to examine the United Verde. Giroux ascertained that the controlling interest in the property was under option to a group represented by James Douglas, so he arranged to have the refusal. Dr. Douglas decided not to exercise his option, because, it is said, he considered the lode to be spotty and the mine too distant from a railroad, whereupon Giroux informed Clark, who came to Jerome forthwith, and, after an examination of the mine, purchased 70 per cent of the stock in the company that owned it. He acquired most of the remaining stock in due course.

Clark began to operate the United Verde in 1889, with success. Giroux was manager. In 1894, shortly after the construction of the Santa Fe, Prescott, & Phoenix railroad, he built a narrow-gauge line from Jerome to connect with this railroad at Jerome Junction. A smelter with a capacity of 3,500,000 pounds of copper per month was then built. Unfortunately this plant was placed over the mine-workings and became endangered by the settling of the ground; moreover, the site was inadequate for the desired expansion of the plant, whereupon in 1912 the building of a new smelter was started in the valley, at Clarkdale. It was completed in 1915. At this time the Santa Fe built a branch of standard gauge to this point. In 1905 the United Verde produced 32,683,951 pounds of copper, together with 486,041 ounces of silver and 15,915 ounces of gold. From the date of its purchase by William A. Clark in 1888 to the end of 1930 the mine has yielded 20,314,000 tons of ore, from which 1,959,098,900 pounds of copper have been extracted, together with 1,009,800 ounces of gold and 34,586,000 ounces of silver. The value of this output has been slightly more than $350,000,000. The United Verde is probably the richest mine that was ever worked under individual ownership. Prior to Senator Clark's death, he and his family owned 95½ per cent of the total (300,000) shares in the company; and since then, by the purchase of the Macdonald holding of 12,500 shares, the Clark family owns more than 299,000 shares of the United Verde Copper Company.

Globe became a mining centre in consequence of the discovery of the Silver King mine, 19 miles southwest, in 1874, at a time when Geronimo and his Apaches were rampant in this region. A good supply of water, obtained from Pinal creek, served to make Globe a distributing point for mining operations in the vicinity.* For a decade the surrounding district produced silver and gold, rather than copper. In 1881 John Williams erected a small copper furnace for the Old Dominion company at a point about six miles west of Globe, to treat oxidized copper ore found in the schist. This locality is now known as Miami. The smelter was called the Carrie plant, because it treated siliceous ore from the Carrie claim. In order to obtain the necessary flux, Williams arranged to pay a dollar per ton for ironstone from the Old Globe outcrop, which happened to contain more copper than the Carrie ore; thus the value of the Old Globe was discovered. Later the Old Dominion, which had ceased operations, and the Old Globe were purchased by Kayser and Simpson. Then the Old Dominion smelter was built at Globe, this event marking the beginning of important copper-mining operations in the district. By 1886 there were six furnaces at work in the Globe district, but they were forced into idleness at the end of that year on account of the low price of copper, which was then quoted at 11 cents per pound. In 1888 the Old Dominion company was reorganized, starting forthwith on a long and successful career. In 1892 Phelps, Dodge & Company purchased the United Globe mines, and shortly thereafter, on the initiative of their resident manager, E. H. Cook, this firm acquired a large number of claims in the Miami area. In 1903 the same firm obtained control of the Old Dominion. At that time sundry small veins of siliceous copper ore had been worked on the Live Oak and Keystone claims,† and their green dumps, now part of the great Inspira-

* T. A. Rickard, *Mining and Scientific Press*, Vol. CXV, p. 161; 1917.

† F. L. Ransome, 'The Geology of the Globe Copper District', U. S. Geol. Survey, p. 156; 1903.

tion mine, serve as a reminder of the small operations in search of oxidized copper mineral that preceded the big-scale chalcocite developments of our own day.

The story of the Miami copper enterprise is a good example of the modern application of scientific knowledge to prospecting, and this must be said timidly in fear that the readers of a later day, familiar with geophysical methods, may take a toplofty mental attitude. In November, 1906, J. Parke Channing, a Columbia School of Mines graduate and a distinguished mining engineer, was at Globe on a visit to the Old Dominion mine. While there he met F. C. Alsdorf, whom he had known in Colorado in 1895. Alsdorf told Channing that in the course of scouting he had found what appeared to him to be a promising deposit of disseminated copper in the hills about six miles west of Globe. Both Alsdorf and Channing were familiar with the 'porphyry copper' type of mine, and Channing especially understood how Lake Superior mining methods and Montanan smelting practice could be applied to a low-grade copper deposit of this kind. They took horses and rode to what is now the Miami-Inspiration district.

Near the western edge of this mineralized area, a ridge of schist flanked by granite, there was an adit, known as the Woodson tunnel, that had been driven in the course of mining sundry patches of rich carbonate ore, and at its farther end this adit had penetrated low-grade material, in which, however, some specks of chalcocite were detected by the two engineers. Together they rode back over the ground, dismounting at intervals to examine the surface, and to discuss the signs of leaching in so far as they gave promise of enrichment below. At the eastern end of this area they came to the group of claims that Alsdorf had under option and that ultimately constituted the property of the Miami Copper Company. Channing examined this ground, and was favorably impressed. The next day he interviewed the several claim-owners and had a talk with the attorney, F. J. Elliott, in whose name several of the options stood. These options called for cash payments

such as were not justified by the condition of the property, which had only a few 10-foot holes without a pound of visible ore. The meeting with the owners lasted until the small hours of the following morning, by which time Mr. Channing, representing the General Development Company, controlled by Adolph Lewisohn, of New York, had taken an option to purchase the property for $250,000, of which $150,000 was to be paid in cash, and $100,000 in the stock of a $2,000,000 corporation. The first payment, of $50,000, was to be made in six months. Mr. Channing returned to New York, and sent Louis A. Wright to examine the prospective mine. The report of this capable engineer confirmed the opinion of Messrs. Alsdorf and Channing that there was a good chance of uncovering a large deposit of disseminated copper. In December, 1906—only a month after the first inspection—two shafts were started: one, on the Captain claim, where there was a showing of carbonate ore, and the other on the Red Rock claim, where the oxidized cap was so thoroughly leached that only a small spot of green could be detected. However, the cap on the Red Rock impressed Channing because it was well silicified and showed residual iron, which was not in excess as on the Red Spring claim farther north. Silicification accompanies the solution and removal of the soluble portions of the rock; an excessive coloration suggests that the downward migration of the copper had not kept pace with the erosion, thereby preventing concentration at a lower horizon.

The two shafts were sunk simultaneously by the aid of gasoline-hoists. At a depth of 100 feet the Captain shaft passed out of copper-stained siliceous schist into rock showing specks of chalcocite, and 70 feet deeper it penetrated the granite, which contained the primary sulphide, chalcopyrite. The granite was cut again in a drift extended northwestward at the 150-foot level, whereas a drift in the opposite direction struck leached schist within a hundred feet. The shaft was sunk to 200 feet, and at that level a drift was driven 70 feet southeast in granite showing pyrite and chalcopyrite. Later

exploration showed that if this shaft had been placed 200 feet to the west, it would have cut a large orebody at a depth of less than 75 feet. The first results therefore were disappointing.

Meanwhile the Red Rock shaft was being sunk through leached cap-rock, and it was not until April, at a depth of 200 feet, that this shaft penetrated suddenly into the zone of secondary enrichment, the schist assaying 3 per cent copper, as chalcocite. The shaft went through 50 feet of this stuff; a level was started from the bottom; and at the end of May the drifts had been extended 50 feet each way to the four points of the compass. The showing was sufficiently encouraging to warrant the first payment, in June. Mr. Channing went to Alaska, and on his return in October he found that 1,000,000 tons of ore had been proved. By March, 1908—15 months from the start—there was 2,000,000 tons of 3 per cent ore assured; the Red Rock shaft, then 710 feet deep, had proved the vertical extent of the orebody, and most of the drifts—2518 feet in aggregate length—were in good ore.

Thereupon the Miami Copper Company was organized in New York with a capital of 600,000 shares of $5 each, a total of $3,000,000. Inasmuch as this was a 50 per cent increase on the capitalization specified under the option, the promoters (the General Development Company) increased the number of shares going to the claim-owners, who then received $150,000 worth of stock. By this time about $150,000 had been spent in development, so that the total expenditure incurred in purchase and exploration was about $400,000. Of the 600,000 shares authorized, 300,000 were delivered to the General Development Company for having found the mine and developed it to that stage, of potential productivity. A block of 200,000 shares was sold at par in order to raise $1,000,000 of working capital. As the mine underwent development it became evident that the million would not suffice, so, later, the 100,000 shares remaining in the treasury were sold at $10 each, raising another million dollars. In 1910 the capital was increased to 750,000 shares, and the extra 150,000 shares

were sold for $2,500,000. Thus altogether there was provided for development and equipment about $4,500,000, in addition to the $400,000 paid for purchase and preliminary development. It is interesting to note how much money is required to convert a promising prospect into a dividend-paying mine. In 1917 the Miami shares were quoted at a price that gave the mine a valuation of $30,000,000; it had paid $11,190,000 in dividends; and a sum of $1,700,000 had been put back in development and improvements. On April 1, 1917, the company had quick assets valued at $7,600,000, of which $2,000,000 was cash. A total of $35,000,000 had been paid in dividends at the end of 1930.

The facts tell the story without the need of rhetorical adornment. It shows how intelligent observation and scientific reasoning can be brought to bear even on that exploratory phase of mining which has seemed usually so haphazard. The sum of $400,000 was risked to ascertain whether there was enough ore to constitute a profitable mine; after that point was passed, the further development underground served merely to emphasize the bigness of the orebody and the consequent need of making financial provision for operations on a big scale. The story of the Miami suggests also that the successful exploitation of an orebody may involve operations on a scale so big as to require the expenditure of sums of money that make the original purchase of the bare ground seem very cheap; it indicates that a mining claim without the intelligent use of capital is only second-rate scenery. The Miami story also shows the camaraderie that exists between engineers of the best type, and the good faith that is kept between them; as also between them and the community. It is worthy of note that Mr. Alsdorf was retained by Mr. Channing to superintend the prospecting operations and that Mr. Elliott was engaged as legal adviser, thus evincing the confidence that existed between the principal parties to the enterprise. To the historian of a later day, these ruminations may probably seem quaint, but, such as they are, they represent the ideas prevalent in our day.

After Parke Channing had bonded the properties now owned by the Miami Copper Company, W. B. Thompson and others obtained options on adjoining property and formed the Inspiration Consolidated Copper Company, while Hovland and Smith bonded and formed the Live Oak Copper Company, these two companies being shortly afterward consolidated into the Inspiration Consolidated Copper Company. The old Inspiration Company erected a test-mill for the treatment of the ore by gravity concentration. The experiments were fairly satisfactory and the Inspiration Consolidated Copper Company had already prepared the foundations for a large gravity mill when the Minerals Separation Company called attention to the results of tests in its San Francisco laboratory made on Inspiration ore. These results were so startling that all construction at Inspiration was stopped for a year while experiments were made with the flotation process, with the result that the Inspiration company changed its concentrator plans from all-gravity to flotation after making a contract with the Minerals Separation Company that was mutually satisfactory. This marked the first important introduction of flotation into the copper-mining industry of the United States.

Another, and later, feature of local metallurgic practice was the successful application of leaching to the ores of the Keystone, Live Oak, and Inspiration mines, all of which contained large tonnages of mixed ore in which half the copper occurred as chalcocite and half as oxidized minerals, such as chrysocolla and malachite. These ores carry only 1·2 per cent of copper; they are too poor for a dual process of leaching and concentration; whereupon experiments were made, and, fortunately, it was ascertained that the regeneration of ferric sulphate could be utilized as a solvent for the chalcocite, as also for the copper in an oxidized condition. George Van Arsdale, at the request of Dr. Ricketts, made a number of experiments at Los Angeles, these being followed by further tests made at the Inspiration mine, where Harold Aldrich and Guy Ruggles developed a leaching process that was embodied in a 10,000-ton plant cost-

ing $6,000,000. This plant has been completely successful; it is extracting 90 per cent of the copper in the mixed ore. Here note may be made of the fact that in the leaching operations at Ajo the regeneration of the ferric sulphate was a nuisance, whereas at Inspiration it was an aid. At both mines the leaching operations attained a precision of treatment new to this difficult branch of metallurgy.

In the early 'seventies Louis Zeckendorf and Albert Steinfeld, merchants of Tucson, were attracted by some copper prospects in Pinal county on Mineral creek, a tributary of the Gila river, and they spent a considerable sum of money in developing these prospects, which were sold to an English company, Ray Copper Mines Ltd., in 1898. The English owners aimed to mine the copper in a diabase dike, and ignored the copper disseminated in the surrounding schist. However, an incline-shaft in the dike happened to pass into the foot-wall country-rock owing to a turn in the dip of the dike, and thus the schist was found to contain a secondary enrichment of copper. The small area of such ore proved by the English company in the vicinity of No. 1 shaft was sampled incorrectly, and, when it was milled, the returns proved disappointing. A 200-ton mill was built at Kelvin, 6 miles south of the mine, at the junction of Mineral creek and the Gila river. Power was obtained from oil distillate, but the engines gave so much trouble that continuous operation proved impracticable. The nearest railroad was 60 miles distant, at Red Rock, on the Southern Pacific line, and as all fuel and other supplies had to be hauled from that point, and the copper concentrate also had to be carried thither by wagon, the conditions were burdensome. The recovery of copper in the mill was disappointing; the schistose ore was supposed to average 4 per cent plus, whereas it contained only 2 per cent plus, and the actual saving in the mill was only about 1 per cent of copper. Operations ceased, and the mine remained idle for several years.

Philip Wiseman, while general manager for the Shannon Copper Company, at Clifton, had heard of the Ray, and went

thither. He had seen the work done by James Colquhoun, who, probably, was the first to treat a disseminated copper ore, at Clifton, in 1896; but it was of comparatively high grade, so that, when he examined the Ray deposit, in 1901, Colquhoun concluded that though there was millions of tons of 2 per cent copper rock, it could not be exploited profitably. Wiseman inferred, from Colquhoun's operations, that ore of this character could be made to pay. Therefore, in association with Seeley Mudd, he secured options on the Ray mine and adjacent properties; these options were transferred to the Ray Consolidated Copper and the Gila Copper companies in 1906. The two companies were consolidated in 1907 under the leadership of Daniel C. Jackling, with Wiseman as general manager at Kelvin. The schistose ground was thoroughly drilled, and thereby about 5,000,000 tons of ore in an area 3000 feet wide by 12,000 feet long was proved, the copper content being about 2¼ per cent. Further exploratory work resulted in the proving of 80,000,000 tons of ore by 1912. The English company had built a narrow-gauge railroad from the mines at Ray to its 200-ton milling plant at Kelvin. This line was re-built in 1908 and the milling plant was changed and enlarged to 300 tons capacity. This mill was used as a testing-plant, preparatory to the erection of a 5000-ton mill, in which the gravity concentration method was used.

It is interesting to trace the germ of low-grade 'porphyry copper' exploitation, for mines in schist as well as monzonite are thus designated. In 1903 L. C. Trent said that a 30 per cent concentrate could be obtained from a 2 per cent copper ore in Utah, meaning Bingham, but it was the mill-testing of Jackling in the Rogers mill at Bingham in 1899 that was the pioneer enterprise in this class of mining, because, unlike Colquhoun, he foresaw the profitable treatment of 2 per cent stuff by ordinary gravity concentration, which, later, was discarded in favor of the more effective process of flotation.

It is noteworthy that the intensive development of the copper resources of Arizona during the last 40 years, a develop-

ment that made Arizona the most productive copper region in the world, was based upon resources that had been known long before, and that awaited railroad building and metallurgic technique to make them the basis of successful industry. The finding of rich ore, at Bisbee and Jerome, for example, attracted capital and engineering skill, thereby starting profitable production, but it was the gradual proving, chiefly by drilling, of immense masses of copper-bearing rock and the subsequent skilful use of metallurgic processes of concentration that enabled the relatively lean ores to become sources of wealth incomparably greater than the *criaderos* and *bonanzas* that first attracted the prospector to the Southwest.

CHAPTER XIII

THE DEVELOPMENT OF THE NORTHWEST

In 1803 the purchase of the immense territory called the province of Louisiana was arranged between Thomas Jefferson, President of the United States, and Napoleon Bonaparte, First Consul of France. This central portion of what is now the United States was claimed in 1682 by the explorer Robert de La Salle for France, who continued to hold her title to the vast domain until 1762, when it passed by treaty to Spain, only to be retroceded to France in 1802, in consequence of Napoleon's military domination of Spain. Jefferson did not care to see New Orleans and its extensive *hinterland* pass into the hands of France. Spain did not matter so much; she was quiet and feeble, whereas France was restless and aggressive under Napoleon, who had dreams of founding a French colonial empire on the American continent. The expression of American feeling that Jefferson elicited came as a surprise to Napoleon, who concluded that a contest was not worth while, for his navy had been shattered by the English, and it was evident that only maritime supremacy could enable him to retain this trans-Atlantic possession; so he resolved to put it out of the grasp of England and at the same time replenish his military chest by selling Louisiana to the United States. The price was 60 million francs.

By the terms of the Louisiana purchase a magnificent territory was added to the national domain; it covered more than a million square miles, or more than the total area of the United States at that time. Louisiana included the present States of Louisiana, Arkansas, Missouri, Kansas, Iowa, Nebraska, South Dakota, North Dakota, Wyoming, Montana, Oklahoma, with parts of Colorado, Idaho, and Minnesota; but

its limits northward were vague, so that historians do not agree as to the precise portion of the country it embraced. If the Louisiana Territory was limited to the watersheds of the Mississippi and the Missouri, it would not include Idaho, which is drained by rivers that are tributary to the Columbia. At the date of cession the entire population of the region, exclusive of the Indian tribes, consisted of 90,000 persons, of whom 40,000 were slaves. The white inhabitants were chiefly French.

In order to explore this new domain, President Jefferson, just before the actual transfer (on April 30,1803), asked the Congress to appropriate $2500 for an expedition, which was placed under the leadership of Captain Meriwether Lewis,* who chose Captain William Clark as the second in command. This famous Lewis and Clark expedition consisted of 27 men, besides the two leaders; 9 were young frontiersmen from Kentucky, 14 were soldiers from the United States Army, and 2 were French *voyageurs*, or boatmen. At that time the country 'beyond' was quite unknown, weird tales were current concerning it, and when the explorers started to cross the headwaters of the Missouri to the upper reaches of the newly discovered Columbia, they were hardly expected to return. The vague notion that Jefferson himself had as to the route likely to be taken by the expedition on its return journey is suggested by his instructions to Lewis, to whom he said: "Our consuls, Thomas Hewes, at Batavia, in Java, William Buchanan, in the Isles of France and Bourbon, and John Elmslie, at the Cape of Good Hope, will be able to supply your necessities by drafts on us".†

Their trail followed the rivers: first, the Missouri to its tributary the Yellowstone, then the Yellowstone and the Jefferson. When they entered Idaho, they encountered the Shoshone Indians at the junction of the Salmon and Lemhi rivers. All went well; they treated the Indians considerately, and received

* He was Jefferson's private secretary.

† Noah Brooks, 'First across the Continent', p. 13; 1912.

kindly treatment in return. The crossing of the Bitter Root mountains was hard and wearisome. The Indians on the western slope were likewise friendly. When Lewis and Clark reached the Clearwater, which they believed to be tributary to

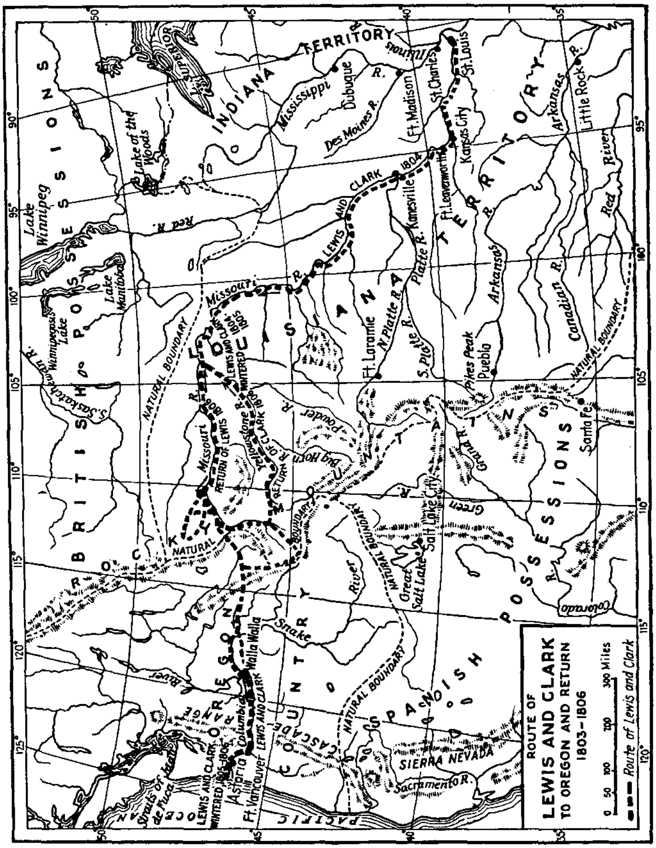


FIG. 23.

the Columbia river, they built five canoes and proceeded down stream. Nine days later they floated into the Great River, the River of the North, or the Oregon, as the Columbia had been variously known to the earlier explorers. On November

2, 1805, they reached tidewater and heard a few words of English spoken by an Indian. They camped on the shore of the Pacific on November 12, eighteen months after the start of the expedition. They returned to St. Louis on September 3 of the following year.

The earliest curiosity concerning the northwestern part of North America was aroused by the idea of finding a short way from Europe to India. The fable of the Strait of Anian enticed the Spanish navigators northward from Mexico, as the similar dream of a Northwest Passage took the English sailors into the Arctic ice. These explorations, during three centuries, from Cabrillo to Cook, yielded much knowledge concerning the navigable rivers of the North American continent and opened the eyes of the explorers to the fur resources of the northern regions. The rivers became the natural highways to the interior, and up them went the early colonists, the trapper and the trader leading the advance. Through the middle of North America, from the Arctic Ocean to the Gulf of Mexico, there runs a wide trough, which is crossed by the valley of the Great Lakes; on each side of them there is a low rim that separates the northern from the southern watersheds, and the streams that formerly connected them. Short portages enabled the French boatmen to link the waterways north of the Lakes with those south of them. Thus the French fur-traders, by making use of the Indian canoe, paddled along a Canadian river into one of the lakes and across it, southward; then carrying their canoe for 10 miles or less, they launched it on a stream that bore them into a tributary of the Mississippi. These portages served to link the water-ways.* After the Mississippi valley had been explored and colonized, the finger of adventure pointed westward, where the ramparts of the Rocky Mountains interposed an imposing barrier to the migration of the people coming from the Atlantic coast. Again a river offered a way of approach

* Ellen C. Semple, 'American History and its Geographic Conditions', p. 28; 1903.

to the trapper and prospector. The Columbia throws mighty arms as far as the headwaters of the Athabasca in the north and as far as the sources of the Colorado in the south; it penetrates the heart of the Rocky Mountains and almost touches fingers with streams that feed the Missouri. Lewis and Clark followed the Missouri, and then its most westerly branch, the Yellowstone, to the mountain barrier, through which they penetrated by aid of an Indian trail over the Lemhi pass, thereby reaching a branch of the Salmon river, which would have led to the Snake and thence to the Columbia; but the Salmon was not navigable, so they turned northward over the range until they struck an upper branch of the Clearwater, down which they floated in their canoes first to the Snake and then into the Columbia itself, to the sea.

The migration of colonists fron the eastern seaboard to the regions beyond the Alleghenies began before the Revolution, but the Lewis and Clark expedition was the first to break through the barrier of the Rocky Mountains and start "the winning of the West". When Lewis and Clark were encamped among the Nez Percés on the Clearwater, they found traces of the white men that had preceded them into the wilderness of mountain and forest, and when they arrived at tide-water they met an Indian that understood their speech. It is noteworthy that the explorers famous in the early history of the West have usually found other white men ahead of them, French trappers, British fur-traders, or American prospectors, who had made friends with the Indians and married among them, becoming 'squaw-men', and being thereby admitted to the aboriginal knowledge of the country. Among these was Carboneau, the French-Canadian trapper that married the famous Sacagawea, a Shoshone woman, with whom he accompanied the Lewis and Clark expedition, to which both husband and wife proved of great service as guides. Another was Drewyer, the son of a Canadian and a squaw, who was particularly helpful in killing game for food in January, 1805, when the same expedition was extremely short

of provisions. Other expeditions were aided similarly. Indeed the term 'squaw-man' has been used unwisely as a term of opprobrium. Were the men that made friends of the Indians and married their women less commendable than those that cheated and murdered the Indians? As a matter of fact, the prospector, no less than the fur-trader, derived much useful aid from the squaw-men because these acted as interpreters and gave them invaluable information concerning the country in which they were seeking either for peltry or for metals. The squaw-man was the pioneer colonist.

The rivalries of the fur companies opened the Northwest to mineral exploration. The commercial activities of Canadian companies operating southward were noted by the government of the United States when it had but newly come into being; the leaders of the young American nation looked askance at the growing influence of foreigners over the aboriginal tribes within its own territory; therefore, in 1796, an effort to counteract these activities was initiated by the American government and an attempt was made to establish trading-posts on the frontier; but this effort failed, because the dull patronage of government could not outvie the keen activity of private enterprise.* What the Government failed to do, the energy and enterprise of an individual succeeded in accomplishing. John Jacob Astor was the man. Astor was born in the German village of Waldorf, near Heidelberg, on the Rhine. During the American Revolution, he started his commercial career in London, where his great-grandson died a British viscount in 1919. In 1783 he determined to follow an elder brother, who had been residing in America for several years. Taking with him a stock of merchandise, bought with his savings, he went to New York, where he sold his merchandise and invested the proceeds in furs, with which he returned to London in 1784. He sold the furs satisfactorily, and came back to New York in the same year. Thereupon he devoted himself, perseveringly and thriftily, to the business of a fur-trader. After sundry

* Washington Irving, 'Astoria', Vol. I, p. 27; 1836.

trade restrictions between Canada and the United States had been removed by treaty in 1795, Astor made a contract with the Northwest Company, which, in 1806, established the first posts beyond the Rocky Mountains, north of the Columbia river. In 1807 Astor started to trade on his own account, ceasing to be merely a broker or middle-man. He had now the requisite capital and resources, but he soon discovered that despite his knowledge and enterprise he could not overcome the opposition of the Mackinaw Company, which controlled most of the fur trade within American territory. He appealed to the American government for help, offering to turn the whole business of that part of the continent into American channels. His plans were cordially approved at Washington. In 1809 he obtained a charter from the legislature of New York State incorporating the American Fur Company with a capital of a million dollars. This capital was furnished by Astor himself; in fact, he constituted the company. In 1811, in conjunction with certain members of the Northwest Company and others engaged in the fur trade, he bought out the Mackinaw Company and merged it with the American Fur Company in a new association called the Southwest Company. This was done with the knowledge and approval of the American government. Unluckily the war of 1812 stopped the operations of the new company, and after the war it was dissolved, the Congress having passed a law prohibiting British fur-traders from doing business within the territory of the United States. Meanwhile ships were going to the Pacific coast to engage in the peltry business. Among them was the 'Columbia', commanded by Captain Robert Gray, of Boston, who discovered and named the great river in 1792.

The reports of Lewis and Clark showed Astor that it was practicable to maintain communication across the continent. He decided to establish trading-posts along the Missouri and the Columbia rivers. At the mouth of the Columbia he would have his headquarters, and to it he would send a ship each year from New York with supplies and with the merchandise

needed for the trade with the Indians. These plans were submitted to Jefferson, who gave his warm approval, because the President foresaw that such enterprise would facilitate the spreading of the American people toward the Pacific coast and thereby promote the growth of the nation. With the approval, therefore, of the Government, Astor organized two expeditions, one by sea and one by land, to proceed to the mouth of the Columbia river. His ship, the 'Tonquin', commanded by Jonathan Thorn, sailed round Cape Horn and reached its destination, on March 22, 1811, after a voyage of 198 days. A site for a trading-house was selected near Point George; it was named Astoria. Meanwhile the land expedition under Wilson Hunt had started from Montreal and proceeded to St. Louis, from which it went in canoes for 450 miles up the Missouri. In crossing the mountains much snow and other difficulties were encountered, but at last Hunt and his party arrived at Astoria, on February 15, 1813, after more than two and a half years of travel. The direct line from St. Louis to Astoria is only 1800 miles, but Hunt had wandered 3500 miles to get there.

The news of the outbreak of war between Great Britain and the United States had reached Astoria, by sea, on January 15, 1813. On October 16 there appeared a vessel with agents of the Northwest Company on board. These contracted for the purchase of the American Fur Company's property at a price of $58,000. Astor's local representatives were largely Canadians with a friendly feeling toward the Northwest people. While the transfer was being concluded a British sloop of war arrived with orders to capture Astoria. The sale having been made, its terms were respected. The American flag was replaced by the British, and Astoria was re-christened Fort George.* The touch of military conquest given to the affair, by the presence of the British warship, caused the restoration of Astoria to the United States under the Treaty of Ghent in

* Reuben G. Thwaites, 'A Brief History of Rocky Mountain Exploration', p. 196; 1904.

1815, but it was held by the Northwest Fur Company until 1821, when it passed with other possessions of that company into the hands of the Hudson's Bay Company.

Most of us have forgotten how much the fur of the beaver was worn in the olden time. Oliver Wendell Holmes wrote:

> Have a good hat; the secret of your looks
> Lives with the beaver in Canadian brooks.

When the silk hat replaced the beaver in 1832, the price of the fur in London fell to one-eighth its former figure.

For ten years after the capture of Astoria, scarcely an American was to be seen in the region. An agreement for joint occupation was made in 1818 between the United States and Great Britain, but this failed to decide the opposing claims and did but accentuate the conflict of interests. The agreement that this part of the country should be open to the peoples of both nations was for ten years, and in 1828 it was extended for ten years more. The Hudson's Bay Company extended its outposts; the Columbia River basin was occupied by British subjects and governed under British law. In the spring of 1811 David Thompson, of the Northwest Company, had tried to forestall Hunt, representing Astor's company, but he had been delayed in crossing the mountains. Nevertheless he laid claim to various places as he descended the Columbia river and erected flagstaffs flying the British colors. On this performance the British government based its right to dominion in 1826. A friendly effort was made to arrange the international dispute. In 1826 the forty-ninth parallel of latitude was accepted temporarily by both parties as the frontier up to the Rocky Mountains. Interest in the controversy grew to excitement as migration over the Oregon trail increased. In 1843 an expedition of 1000 persons, including women and children, with herds of cattle and horses, trekked from Missouri to the valleys of the Willamette and Columbia. In 1844 another company of 2000 immigrants of like character joined them, and in the following year 3000 more. The

Hudson's Bay agents objected to this peaceful invasion because it spoiled their fur trade. Congress was slow to act, but, thanks to the exertions of Senator Thomas H. Benton, a treaty was drafted amicably in 1846, the British protocol being accepted, whereby "the Oregon territory was divided by the 49th parallel from the Rocky Mountains to the Straits of Fuca, and thence by a line following the main channel of these straits to the sea".* Two years later, in 1848, Oregon was created a Territory. In 1859 Oregon became a State.

The foregoing account of the extension of the fur trade, and its resulting international disputes, is necessary to an understanding of the beginnings of mining in the Northwest, because, as in the Mississippi valley, at an earlier period, the fur-trader prepared the way for the prospector. Between the seeker of furs and the searcher for minerals came the missionary, who tried to save the soul of the Indian while his enterprising friends were succeeding in dispossessing the poor aboriginal of his earthly possessions. Thus the mineral resources of the Northwest were opened up. In 1810 the Missouri Fur Company established a post on the Snake river and in 1811 a party of the Pacific Fur Company, controlled by Astor, descended the Snake to its junction with the Columbia. Then came missionaries, both Romanist and Protestant. These traveled along the trails that the trappers and packers had established across the Bitter Root range, which separates Idaho from Montana. In 1841 Father De Smet, a Jesuit priest, descended into the valley of the Coeur d'Alène river and ministered to the Indians of that name, a name they owed to a tricky trader, whom, when he tried to get the best of them, they called, in the French that they had learned from the Canadians, *coeur d'alène*, or heart of an awl. The other traders, for lack of a better name, thenceforth spoke of these Indians as the Coeur d'Alènes. They were a docile tribe, and begged De Smet to establish a mission among them, as was done in 1842. It

* Robert McNutt Elroy, 'The Winning of the Far West', p. 127; 1914.

was trade with these Indians that led to the discovery of the mineral wealth of the region.

In the spring of 1849 the gold excitement in California attracted many of the pioneer settlers from the Northwest. Ten years later gold was discovered in the Similkameen valley, but these diggings proved to be in British territory, as American traders soon realized, when they were taxed $100 for the privilege of doing business there. In August of the following year, 1860, the placers of the Cariboo, at the head of the Fraser river, were made known and soon drew the usual motley crowd of eager gold-seekers. Some of the claims yielded from $8 to $50 per day per man. Five men in one company took out $2400 in gold in six days. The reports from Cariboo started a renewed search for gold along the northern border-lands of the United States, one consequence of which was Pierce's discovery in the valley of the Clearwater.

To E. D. Pierce belongs the honor of being the pioneer of mining in Idaho. He was a trader among the Indians and through them he had long known that the country east of the big bend of the Snake river was gold-bearing, but he did not care to undertake prospecting operations for fear of arousing their enmity. He had been in California and knew something about placer mining. In 1858 Pierce went to the district of the Nez Percé Indians, but found no opportunity to search for gold until the ratification of the Nez Percé treaty in 1860, which event marked the cessation of hostilities between these Indians and the white settlers. Early in the same year he was enabled to verify his belief that there was gold in the gravel of the Clearwater, a branch of the Snake, and he so reported in April at Walla Walla, which was the nearest distributing point. Pierce did not return at once to the Clearwater, on account of opposition from both the Indian and the military departments of the Government. These dreaded a renewal of trouble with the Nez Percés and the Spokanes in the event of a mob of prospectors over-running

their reservations.* In August, of 1860, however, Pierce was able to set out from Walla Walla for the purpose of making a conclusive examination. He appears to have been a careful and sagacious man, unwilling to commit himself to an opinion until sufficient evidence was forthcoming. He ascertained that the diggings would yield from 8 to 15 cents to the pan. Having satisfied himself that profitable mining was feasible, he tried to organize a large number of men to return with him and remain on the ground during the winter, but the fear of attack by the Indians was a sufficient deterrent to the adventure, so that only 33 men were willing to accompany him. By the time 300 men had set to work on the Clearwater, at a place named Oro Fino, a treaty was negotiated with the Indians. This was in the spring of 1861. By July fully 5000 men had scattered over the surrounding district, and prospecting had extended to the south fork of the Clearwater, where Elk City was founded.

From the mining-camps of Pierce City and Oro Fino, in the Clearwater valley, the restless prospectors roamed southward to the other tributaries of the Snake river. In September of 1861 an exploring party found rich gravel on Miller creek, which was named after one of the discoverers, Joseph Miller. This was on a branch of the Salmon river, in what is now Idaho, and was then in the Territory of Washington. An eager rush ensued, the exaggerated reports of big winnings having the effect of depriving Oro Fino and Elk City of a large part of their vagrant populations. John Munsac, we are told, purchased a claim for $1800 and "from two pans of the dirt took four ounces of gold". In two weeks he obtained 45 pounds of 'dust'.† The hostility of the Shoshone Indians, however, troubled the diggers, and an unusually severe winter (1861–1862) checked placer operations. Meanwhile 700 men had congregated along the creeks and "every kind of provisions

* 'The Works of Hubert Howe Bancroft', Vol. XXXI, p. 235; 1890.

† H. H. Bancroft, 'History of Washington, Idaho, and Montana', p. 247; 1890.

was worth a dollar a pound, except beef, which was still cheap". It is recorded that there were 186 claims on Miller creek; these were worked by 558 men, who gathered $2,785,536 in eight months. In the spring of 1862 a large number of miners arrived from California, and from elsewhere, so that in June fully 20,000 men were distributed among the various diggings on the Clearwater, Salmon, Powder, and John Day rivers.

Prospecting farther southward was resumed; a party of 12, under the leadership of George Grimes, left Auburn, in Baker county, Oregon, and proceeded up the Snake river as far as Sinker creek. Then they advanced to the Boise river, which they crossed on a raft, to halt at the place where Boise City now stands. In August they reached the higher ground, where they found several creeks rich in gold, but they were attacked by some Shoshones that had been following them for several days, and Grimes was killed. As they were too few to face further attacks, the party returned to Walla Walla in September, bringing about $4500 in gold-dust with them. This caused excitement, and incited the organization of another expedition of 54 men, well armed, who reached the Boise basin on October 7, 1862. They built cabins, and a stockade. Others came soon, attracted by the rumors of rich gravel. The best diggings were 70 miles due east of Fort Boise, which is on the Snake river. This was a beautiful country and it has become celebrated since then for its agricultural productivity. At that time it was in the eastern part of the Territory of Washington, but in 1863 the portion of Washington lying east of Oregon and of the 117th meridian of west longitude became the Territory of Idaho.

Grimes creek, named after the unfortunate leader of the first expedition, proved to be the richest in the Boise basin. Eighteen dollars a day was the usual gain. One pan of gravel, we are told, yielded $80. Soon ditches were constructed and the mining operations became more systematic. The Indians were still menacing, so a company of 200 men made a reconnaissance for the purpose of reprisals. A number of the natives

had taken an advantageous position on high ground, from which they could not be dislodged until "by artifice the Indians were induced to surrender, and thereupon nearly all were killed by the ruthless white men in revenge for their murdered comrades". Men, women, and children were shot, only three small boys escaping. That is typical Indian warfare as it was understood in frontier days.

In 1863 the Boise mines drew 25,000 into southern Idaho. During June quartz veins were discovered, the Pioneer, on Granite creek, and the Elmore, on Bear creek, being the mines that proved the most productive in later years. Among the settlements then founded were Rocky Bar and Boise City. At this time a party of prospectors searching for some 'lost diggings', said to have been worked by the immigrants of 1845, went south of the Snake, and in the watershed of the Owyhee river they found good placers along a creek named the Jordan, after one of the discoverers, Michael Jordan. The gravel deposits were small in extent and many of the diggers that rushed thither were disappointed; moreover, the gold was alloyed with so much silver that it was worth only $10 per ounce. This indicated the nearness of veins containing both gold and silver; indeed, shortly afterward, in July, several veins of rich silver ore were found. The discovery of silver caused keen interest, and the people of Oregon were sorry to be told, as soon as a survey was made, that the Owyhee silver deposits were inside the newly organized Territory of Idaho. Boonville and Ruby City were founded, and soon afterward, Silver City.

Most of the productive mines in the Owyhee district, such as the Poorman, Ida Elmore, and Golden Chariot, were on War Eagle mountain.* Shipments from the district in three years, 1865–1868, amounted to $2,969,648. The veins traversed granite and were remarkable for their hornsilver, the chloride, which was found in crystalline masses of remarkable beauty. Some pieces of this soft mineral were in sheets a sixteenth of an

* William Ashburner, 'Mineral Resources of the States and Territories', p. 161; 1869.

inch in thickness and more than a foot square. Fourteen tons of ore shipped from the Poorman mine in 1866 to Newark, New Jersey, yielded $4000 per ton. From July to November, 1866, the Poorman yielded 2382 tons, which, by treatment in four different mills, produced $546,692.

The Poorman vein was discovered in the summer of 1865. At the place of discovery the vein was small and the ore was not rich. Soon afterward a prospector named Peck found some rich float at a spot about a thousand feet south of the discovery shaft, where the locators, Hays and Ray, were at work. By a little digging, Peck uncovered a rich vein, and promptly covered it, so as to hide his discovery. Then he collected all the rich float he could find and hid that also. His operations were out of the sight of his neighbors, to whom he went subsequently and with whom he talked in a casual way until they had told him how far their claim extended. He ascertained that it included the rich ground he had uncovered. He tried to buy their claim, but nothing was done; whereupon he left the locality, thinking it wise to dissemble his interest in the matter. On his return he found that some other prospectors had discovered his rich spot, had located a claim, and had already mined some handsome ore. Hays and Ray claimed this ground, and Peck undertook to help them, but the jumpers obtained monetary aid, built a fort, and prepared to resist eviction. A compromise was effected, but the mine suffered from subsequent litigation. The company that owned it was named the New York and Owyhee Mining Company; it is noteworthy that the manager in 1867 was John M. Adams, the first graduate from the Columbia School of Mines. Miners were paid five dollars per day. It is recorded: "The Chinese find limited employment, at a great reduction, but the prejudice existing against them is as strong in Idaho as elsewhere, and the Indian difficulties have prevented any large immigration".

Oregon had its share of mining excitement. Marshall, the discoverer of gold in California, had been an immigrant to

Oregon in 1884,* and with him at the time of the discovery at Coloma, in 1848, were two others from Oregon. As soon therefore as the news came from California, most of the able-bodied men in Oregon rushed thither. The Territorial legislature had to suspend its sittings for lack of a quorum. Flour and lumber were exported freely from Oregon to the new camps in the Californian goldfields, and the farmers of the northern Territory profited greatly. The fur trade suffered depression, and this facilitated the eventual settlement of territorial rights by causing the retirement of the Hudson's Bay Company, and the recognition of American rights, resting largely on Astor's pioneer enterprise. A considerable part of the migration westward to California followed the northern route. In 1850 there came 35,000, chiefly men, by the overland route to the Pacific coast, and 8000 of these settled in Oregon, where the gold discoveries were relatively unimportant and consequently did not interfere with the more quiet and fundamental development of agriculture. In 1850 gold was found on the Klamath, in northern California, and this led two years later to similar discoveries on Jackson creek in Oregon itself. In 1861 there were finds of gold on the John Day and Powder rivers in eastern Oregon, but none of these events caused any such excitement as the rushes to the American river in California or the Fraser river in British Columbia. These were decisive events.

The rush to the Californian diggings attracted many men from the country north of the Columbia river, now the State of Washington, and delayed the development of the less feverish industries, such as the agricultural and pastoral; but the rapid settlement of the Pacific coast consequent upon the migration stimulated by the gold discoveries had a quickening effect upon the whole of the Oregon Territory.† The exportation of grain and lumber to California enriched the settlers in

* The year in which Oregon was organized as a Territory.

† H. H. Bancroft, 'History of Washington, Idaho, and Montana', p. 13; 1890.

the Northwest. Many of the gold-diggers returned from the south with the capital needed to develop the resources of their home locality; they busied themselves in felling timber for the saw-mills that provided the piles for the new wharves of San Francisco and the lumber for the city that was being built on the Golden Gate. The early settlements of Olympia, Port Townsend, and Seattle were lumber centres. Seattle was founded in 1852, and was named after an Indian chief that was held in high regard by the pioneers. In 1855 a discovery of gold in the Willamette valley, near the site of Fort Colville, which was established four years later, caused a short-lived excitement. During the rush to the Fraser River placers, in 1859, many of the returning prospectors stayed in the Willamette valley and explored the upper reaches of the Columbia as far east as the Bitter Root valley, where they made five or six dollars per day. Some soldiers from Fort Colville discovered gold on the Similkameen river in October, 1859, and nothing could stop another stampede, followed by the organizing, in November, of a number of stock companies at Portland.

The Northwest, as a mining region, was opened up first by the trapper and squaw-man, followed by the fur-trader. These blazed the trail over which came the prospector, a placer miner, who, through the Indians, heard of the occurrence of gold in some of the stream-beds, and forthwith used his pick and pan in the search for profitable alluvium. The working of the placer deposits attracted men that were experienced in the mining of the ores of the base metals and thereby led to the exploitation of the big silver-lead deposits of the region. By the establishment of mining communities in the mountains there was created a market for the produce of the farmers in the valley; and so, in due course, an industrial civilization was founded.

CHAPTER XIV

THE BUNKER HILL ENTERPRISE

For many years the occurrence of gold in the Coeur d'Alène region had been rumored among the pioneers of the Northwest. It is stated that as early as 1853 gold was discovered in this district by Donelson, of the Stevens expedition, but the hostility of the Indians prevented prospecting. In 1858, when Lieutenant John Mullan surveyed the military road across the Bitter Root mountains, the members of his expedition, most of whom had mined in California, noticed sundry outcrops of good-looking quartz, and some of them actually found gold, as is recorded in a letter that Mullan wrote, from Washington, in 1884. The first successful prospector in the Coeur d' Alène was Tom Irwin, who worked a quartz vein on the Mullan road in the spring of 1879. Two years later he met A. J. Prichard, who was engaged in the lumber business; he told him what he thought of the chances of placer mining in the upper reaches of the Coeur d'Alène river. This was in 1881. Prichard became keenly interested, and himself found gold on several creeks, one of which is now known by his name, at a place close to the site of the town of Murray.* In 1883 Prichard located a number of claims, and shortly afterward he wrote a letter to the members of a Liberal League to which he belonged, inviting them to "secure the lion's share" of the mineral wealth he had uncovered. His letters caused a stampede from Montana and Colorado, and from South Dakota also, to the Coeur d'Alène gold belt in the summer of 1883.

A town, named Eagle City, was surveyed; in 1884 lots sold at prices ranging from $200 to $2000. The buildings were made of logs and shingles. Shoveling of the snow in front left a

* T. A. Rickard, *Mining and Scientific Press*, Vol. CXX, p. 13; 1920.

mound between the houses and the street. From big tents, with gaudy signs, came sounds of barbaric music, the click of poker chips, and the clink of coin over a bar. At the corners stood groups of men talking about mines and mining,

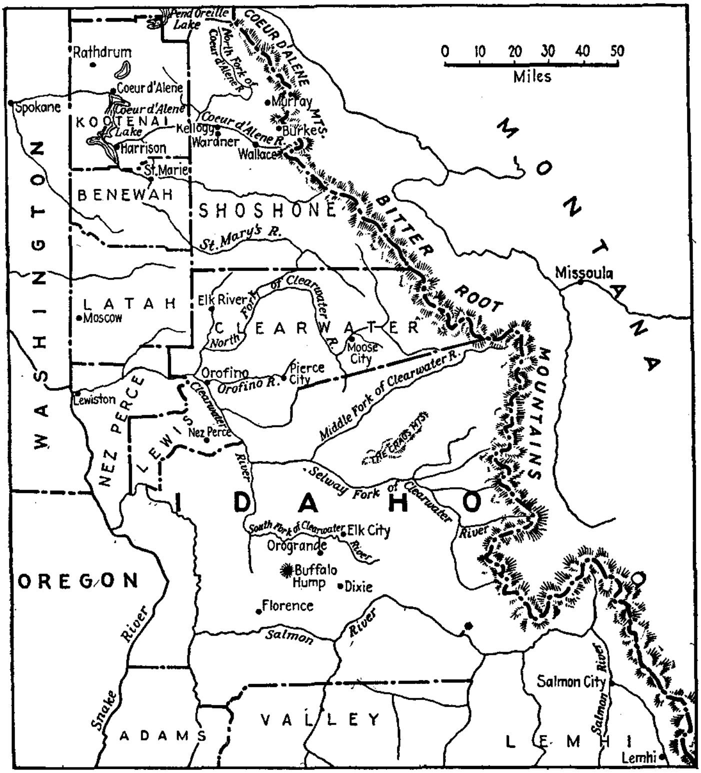


FIG. 24.—Map of Idaho.

some of them examining specimens as they were passed from hand to hand. The stores exhibited lumps of gold-bespattered quartz. A pistol shot would cause a transient flutter and the saloons momentarily disgorged a motley crowd. Pack trains arrived, weather-worn and dilapidated from hard travel, and

after them came the poor fellows that had dragged their belongings on sleds and toboggans over the snow-covered trail across the mountains from Thompson Falls, their ardor having been excited by the flamboyant advertisements issued to 'boost' the newly constructed Northern Pacific railroad. Amid the hubbub of arrival, there were cheerful sounds of greeting and the laughter of care-free young men. The hammering of the carpenters indicated the growth of the town. An air of expectation pervaded the community; the town was full of life and hope—a transitory gleam. Eagle City soon lost its plumage; other 'cities' sprang up like mushrooms in the night; among them were Carbon City and Myrtle; each had its short splutter; their sites are hard to find today. It would be difficult also to discover the place once occupied by the town of Delta, the birthplace of David Levinger, recently a director of the American Institute of Mining and Metallurgical Engineers, and the manager of the Development Department of the Western Electric Company, the largest single consumer of lead in the United States.

Murray was one of these early mining centres. The firm of Cooper and Peck owned a store of general merchandise in that town. During the summer of 1885 they grubstaked a prospector named Noah Kellogg. In frontier communities 'grubstaking' used to be a recognized form of mining speculation; it consisted in supplying a prospector with food and tools, in return for which he undertook to give his backers a half-interest in any mineral discovery he might make. Kellogg was provided with a donkey and \$18·75 worth of supplies and provisions; these consisted of 15 pounds of flour, 7 pounds of bacon, 8 pounds of beans, 4 pounds of dried apples, 2 pounds of coffee, \$1 worth of sugar, one pair of \$2·75 shoes, and half a dozen printed location notices. He was to prospect on the south fork of the Coeur d'Alène river for gold, because it was for gold that they were looking, and it was in gold-mining that Kellogg was supposed to be proficient. He started on August 1, and returned four weeks later, having consumed the

provisions with which he had been supplied. All that he had to show were some pieces of ironstone that contained a little lead, as galena; these specimens did not interest Cooper, to whom they were shown, but later Kellogg took them to Philip O'Rourke, who had been to Leadville, in Colorado, and who knew something about silver-lead ores. The Irishman offered to go with Kellogg, who, apparently, considered that his agreement with Cooper and Peck had terminated. A day or two later the two prospectors went together down the south fork of the Coeur d'Alène river, Kellogg stopping at Big creek while O'Rourke went on to Milo creek. Next day, September 4, near the head of the gulch, O'Rourke picked up a piece of iron-stained mineral which, when he broke it, showed galena inside. He found similar 'float' up the hillside, and was led thereby to the outcrop of the Bunker Hill lode. He located a claim. Four days later Kellogg joined him, and they located more claims; then together they returned to Murray, where they exhibited their specimens to sundry friends, but not to either Cooper or Peck.

Litigation ensued, of course, because Kellogg had broken faith with his backers. The District Court awarded a fourth interest in the Bunker Hill claim to Cooper and Peck. Nevertheless the story persists in the Coeur d'Alène that they were given a half interest by the Court because it decided that the 'burro' was the real discoverer of the lode. Kellogg's yarn, which blooms perennially, was that the donkey went astray and that he found the animal mesmerized by a brilliant mass of ore. In the memoirs of Jim Wardner, a promoter well known throughout the Northwest, the tale of Kellogg is given thus:

"Looking across the creek we saw the jack standing upon the side of the hill, and apparently gazing intently across the canyon at some object which attracted his attention. We went up the slope after him, expecting that, as usual, he would give us a hard chase; but he never moved as we approached. His ears were set forward, his eyes were fixed upon some object,

and he seemed wholly absorbed. Reaching his side, we were astounded to find the jackass standing upon a great outcropping of mineralized vein-matter and looking in apparent amazement at the marvelous ore-shoot across the canyon, which then, as you now see it, was reflecting the sun's rays like a mirror."

This is a mere concoction, and it may seem frivolous to quote it, but the story of Kellogg and his burro is as much a part of mining tradition in the Northwest as was that of Jason and the Golden Fleece among the Greeks in the dawn of mining adventure. Neither Wardner, nor Kellogg, nor the gentle jackass, nor even the keenest of observers ever saw a glistening mass of galena outcropping there or anywhere else in nature. Galena oxidizes when exposed to the weather and loses its bright lustre, becoming the dull sulphate or the equally dull carbonate, which usually is colored red by the oxidation of a small proportion of associated iron pyrite. The outcrops of lead lodes consist commonly of dark-red ironstone with gray spots of anglesite (the lead sulphate) or cerussite (the carbonate) in the midst of which unoxidized remnants of galena may survive. Portions of the Bunker Hill outcrop can still be seen near the place of discovery; they consist of iron-stained quartzite containing specks of lead mineral. The talk of a glittering mass of silvery ore sticking out of the mountain-side so brilliantly as to mesmerize the ass, and others not any wiser, is pure moonshine. What did happen probably is that the donkey, intelligent enough to find fodder for himself, strayed through the pine forest above the creek toward the outcrop, because near it, on account of the mineralization, there was a bit of open space covered with bunch-grass.

Jim Wardner joined with the locators in raising the capital needed to develop a mine; he took samples of the lead ore to Spokane, where the assayers found that it was rich in silver as well as lead. Wardner returned to the mine and contracted to buy 25,000 tons of ore, he to advance the owners $5 per ton and they to produce not less than 20 tons daily. About 800

tons of ore was taken out of the mine, on which Wardner received $115 gross per ton, and which he sold to the Selby smelter at San Francisco. But the effort seemed to exhaust the orebody; the bottom of the workings showed only stringers of galena in a wide lode. Whereupon a tunnel, or adit, was started from the gulch into the hillside to cut the lode at a greater depth. This intersected 36 feet of fine-looking ore, but it was too low-grade for shipment to a distant smelter; it had to be concentrated. In 1885 Wardner went. to Sam Hauser, at Helena, Montana, and persuaded him to find the money for a 100-ton mill, while he himself was to obtain a contract from the owners of the mine to concentrate 50,000 tons at $5 per ton. All went well. The mill soon put the mine on its feet. In consequence, it was sold to Simeon G. Reed, of Portland, for $650,000, on the report of Joshua E. Clayton, in 1886.

The Bunker Hill & Sullivan Mining & Concentrating Company was incorporated under the laws of Oregon on June 29, 1887, with 300,000 shares of $10 each, of which Reed held 249,988 shares. Victor Clement was appointed manager; on his advice a tramway and a new mill were built. In 1891 the new mill at Kellogg, with its Bleichert tramway, was at work successfully. The records show that although 213,108 tons of ore was mined up to May 31, 1892, for which the smelter made returns of $1,923,083, yielding an operating profit of $899,601, the company was unable to provide the money required for the needed plant and equipment, whereupon it was arranged that D. O. Mills, of San Francisco, should buy 50,000 shares at $3 per share, and another block of 50,000 shares was taken at the same price by James L. Houghteling and friends of Chicago. Even these funds proved insufficient, so a loan of $60,000 was obtained from the First National Bank of Portland. The indebtedness to this bank increased to an embarrassing degree, so W. H. Crocker, of San Francisco, was persuaded to loan the company $110,000 at one per cent per month; and he became a director, continuing throughout the

later history of the enterprise to be its stalwart financial supporter. It takes money to make mines, especially large mines needing mills and smelters. Further loans were required before the Bunker Hill enterprise was finally successful, and long before that the small holdings of the original owners, Kellogg, O'Rourke, Wardner, and Sullivan had been largely absorbed by the capitalists to whom reference has been made, and the remainders of these small holdings were eventually absorbed by outside speculators.

In 1893 Clement went to South Africa and was succeeded as resident manager by Frederick W. Bradley, who, in turn, was succeeded by Albert Burch in 1901, to be followed by Stanly A. Easton in 1903. Mr. Easton is still the manager. Mr. Bradley has been president of the company since 1897. The Bunker Hill is a good example of the dominance of the engineer in the control of the operations and the policy of a large mining undertaking. In 1894 the first dividend was paid. The average working cost for 32 years was $2·54 per ton. For 22 years the yield averaged 11·28 per cent of lead and 4·92 oz. of silver per ton. The Guggenheims bought the shares of Clement's widow in 1905 and endeavored later to gain the control, but without success. Crocker, Mills, and Bradley continued to be the dominant factors.

The labor disturbances, and riots, of 1892 and 1899, crippled the operations of the Bunker Hill company and gave a sinister fame to the Coeur d'Alène. Such episodes, unfortunately, were a characteristic feature of mining in western America during the last quarter of the nineteenth century, and the historian must not ignore them. In 1890 a Consolidated Miners Union was organized in the Coeur d'Alène, and in 1891 a Mine Owners Protective Association was formed. The two sides, workers and employers, were preparing for the conflict. It started over a minor matter.

In July, 1891, the Wardner union presented a demand to the manager of the Bunker Hill, at Kellogg, for the discontinuance of the arrangement whereby the men paid a dollar

per month for medical services, without hospital facilities; instead, it was asked that a similar amount be deducted from each man's pay in behalf of the Central Miners Union Hospital at Wallace, which is 10 miles from Kellogg. The manager declined to accede to these demands and invited such of his employees as objected to 'get out'. A strike ensued. Sundry outrages were perpetrated. A compromise was reached in December, but other disagreements arose at several mines within the district, and, as these synchronized with a dispute between the mining companies and the railroad companies over freight-rates, all the principal mines closed down on January 15, 1892. In March it was announced by the Mine Owners Association that satisfactory arrangements had been made with the railroads and that the mines would resume work, but only \$3·00 per day would be paid to car-men and shovelers as against \$3·50 per shift of 10 hours to all miners.

The temper of the two sides, and the sentiments underlying their actions, is expressed in their public statements, the purpose of which was to enlist public sympathy. In the announcement made by the Mine Owners Association, it was said:

"This scale of wages, after much consideration, has been determined upon as liberal and fair by the Association and it is hoped that it may meet the approval of all old employees as well as the public generally. The Association also announces that in all tunnel mines where a majority of the men desire to avoid working Sunday and Sunday night they may, on giving expression of such desire to the manager, have Sunday and Sunday night off each week. While we have no objections to miners unions if they are governed and conducted by able, sensible, real miners, it is nevertheless a fact that during the years we have had unions in this country there has been trouble somewhere most of the time, strikes and threats of strikes, committees and delegations continually, to the great annoyance and loss not only to the miners but also to the community generally as well as the mine-owners, and we

challenge anybody to show in what manner the miners or owners or the community have been benefited one cent's worth for all the trouble caused, for all the time lost, for all the hard feelings engendered, for the many hard-earned dollars which the working miners have contributed to the coffers of the unions, excepting in the matter of the Sisters Hospital, which is a notable institution and worthy of generous support . . . The only men who can be said to have been benefited at all are the car-men and shovelers, worthy men, no doubt, but it is well known that any reasonably intelligent man can learn to do this work in tunnel mines in a few days, and can it be said that these men are entitled to the same pay as skilled miners, who have spent years in learning their trade? We have endeavored many times to learn by what reason the unions demand the same pay for these men that they do for miners, but have failed entirely to get any good reason . . . Even admitting that the danger is equal to both miners and car-men alike, we would ask if the world's work is paid for without regard to skill? Does the locomotive fire-man get the same pay as the engineer? . . . It is true that the mine-owners raised the wages of car-men and shovelers last year at the demand of the unions, but they did so under protest and with a keen sense of its injustice. However, at that time lead and silver were much higher than at present, and desiring to get along amicably with the unions and being able to afford it, the wages of car-men and shovelers were raised. Now the conditions have changed; lead is only four cents and tending downward. Silver is below 90 and going lower, and the mine-owners are therefore under the necessity of the strictest economy."

I should like to quote *in extenso*, but space forbids. The pronunciamento of the mining companies proceeds to say that the trouble with the workers is entirely a matter of business, that the ores are low-grade, and that strict economy is imperative. Moreover, the capitalist followed the prospector into the region, and with the money and skill of the capitalists the

mines were developed and equipped. Why then these threats to run them out of the country, to burn their mills, blow up their flumes, and even murder them? Does this talk of riot and murder do anybody any good? Who are the cause of it? A few agitators, not real miners, who terrorize the community, "their sole purpose being to keep up a continuous state of turmoil and strife to the end that tribute may in some way or another come to them". Then the unions are warned by the mine-owners that any losses due to the destruction of mills or other property will have to be paid by the county. They seem to anticipate events. They expect that any concession will be followed by fresh demands. They ask "if many of the leaders have not made up their minds that if they are successful in the present conflict, they will within 60 days urge a strike for $4 a day for miners, for the closing of company boarding-houses, for a boycott on all business enterprises in which any mine-owner has an interest, for a rule that no miner be allowed to work in any mine in the Coeur d'Alène over seven days unless he joins the union, if not freely then by force, that no mine foreman shall discharge any man underground until he has given a satisfactory reason for so doing to the union".

Again it is evident that the mine-owners anticipate the union program with considerable confidence. Their statement is long and discursive; it shows how warm the controversy had already become. It was not a fight between employer and employee, but between the owners of the mines and a group of agitators from the outside. The statement concludes by saying:

"We will simply add that we have determined that the wages cited are fair and liberal, and all we ought to be asked to pay, and having so determined we do not mean to start up our mines at any higher wages. We will wait until the first of April for our men to make up their minds, and if they decline to accept, we will have no other course but to claim the right to work our mines (which we paid for and own) outside of any unions, and we are fully determined to do so without any

dictations from any association, conceding, however, the right to every person to demand any price they see fit for their labor as long as they do not interfere with the rights of others, and we feel confident the law will uphold us in so doing."

To this the Central Miners Union of the Coeur d'Alène replied immediately, in terms that indicated an unrelenting struggle. The spirit of the reply is suggested by the opening paragraph:

"As miners, we are not gifted with the literary abilities of the hired attorneys of the Mine Owners Association, nor at the same time with the talent of making statements so absurd and false as to cause a blush of apology on the cheeks of Ananias, but as working-men we ask a thoughtful and considerate public to view both sides of the question before forming an opinion as to the merits or demerits of the case brought before their notice."

As a critic, I should say that the statements of the two parties do not differ greatly in literary style, and it is a safe guess that both of them were prepared by "hired attorneys". The Unions assert that "the late shut-down" was not due to wages but was intended "to crush out organized labor" and to introduce contract labor. They insist that the owners have made big earnings on their capital, except where the mines have been mismanaged. They complain of the condition of the lodging-houses and the quality of the food provided by the companies. They deny that the increased rate to the car-men was made under protest, and that in certain mines the higher rate had been paid previously without the solicitation of the miners union. They proceed to say: "The Mine Owners Association conveys the idea that we are nothing more nor less than a band of anarchists continually threatening the destruction of life and property, liable at any moment to carry out such threats if necessary to accomplish our purpose". They ask where and by whom such threats were made. The history of succeeding events records the fact that the mine-owners were better prophets than managers and that the

Union fulfilled the worst anticipations of its opponents. The question uppermost in strikes is touched:

"There is no doubt that the mine-owners would not object to the unions provided they were officered by their nominees, but to this every member objects, as they should, in order to maintain some independence that in future as in the past they might be in a position to direct their efforts to mutually benefit all working-men and by lawful means, and to state that the central or any other local union means in the future to select a county ticket to be voted on in the fall is a falsehood without a vestige of truth . . . As for coercion in order to enlist members, the people here know well we have never used the like with one-half the force the Association has done to compel outside mines to fall in line. Will the Mine Owners Association allow their constitution to be perused by the public? We think not, because from information now in our hands we know it is so opposed to law and order that the darkened archives of the Association is its safest retreat."

The proposal of the mine-owners was rejected; the mines were closed and notice was given that new arrangements would be made to re-open them for work in June 1 (1892). Before that date the managers began to import miners from the outside under the guard of detectives. They also obtained injunctions from the Federal court, and served them on a number of persons, restraining them from interference with the operation of the mines. During June the mines were run short-handed and intermittently, chiefly by non-union labor. The 'History of North Idaho' says:

"The mines that came under the special displeasure of the union men were the Bunker Hill & Sullivan, at Wardner, and the Gem and Frisco, on Canyon creek. At the Canyon creek mines the feeling between the union strikers and the non-union men who had taken their places and were working under guard was very bitter. Exchanges of harsh words were frequent and fist-fights were not uncommon. These eventually precipitated an armed encounter of July 11th between union

men and the employees and guards of the Frisco mine. At about five o'clock in the morning of that day the firing commenced. It is said by both sides that the shooting was not intended at first to do more than frighten the men out of the mine. Soon, however, a pitched battle resulted, both miners and guards firing to kill. The strikers were at a disadvantage, so withdrew up the hills. It was now that the plan of destroying the mills took shape in their minds. They came to the the end of the tramway, placed some giant powder in a car and started it to the buildings on its errand of destruction. The fuse was too short, so the explosion took place too soon to do serious damage, though the tramway was destroyed. Powder was then carried to the flume and, the water having been turned off, sent down the penstock and to the water-wheel. The old mill was thus wrecked, but fortunately most of the men had withdrawn to the new mill, thus saving their lives. The men in the mill continued firing a short time, but soon realizing their hopeless position, surrendered. Soon the battle began at the Gem. The men in that mine had made some preparation by erecting barricades of wood and lumber. As the night shift was going off and the day force going on, the firing began. After a large number of shots had been exchanged by the strikers in the town of Gem and by the men at the mine, a conference was held under a flag of truce, in which it was agreed that the non-union men should surrender if so advised by A. L. Gross, the only member of the Gem company in the country. Gross advised the surrender and the men handed over their arms."

In the two battles two non-union men were killed, namely John Starlick and Ivery Bean, also three strikers, James Henessy, Gus Carlson, and Harry Cummings.* A considerable number were wounded. After their victories at the Gem and the Frisco the strikers proceeded to Wardner, going from a point outside of Wallace to the junction in two freight-cars propelled by gravity. They arrived after

* The names bespeak racial origins.

dark on the night of the 11th, took possession of the Bunker Hill concentrator and placed a ton of powder under it. Next morning Mr. Clement had the choice of discharging his non-union employees and sending them out of the country or having his mill blown to pieces. Under the circumstances he agreed to send the men away, which was done. Martial law was promptly declared, and under the protection of the soldiers many of the expelled non-union men returned. With such help, the Bunker Hill & Sullivan Company resumed work before July 1. Many of those who were most active in the uprising were compelled to flee from the country; many others were placed under arrest, but only a comparatively few were convicted and punished. Gradually the troops were removed, and on November 18, 1892, martial law was revoked.

It is a miserable story. Even the shooting was poor! Think of all the gun-play that took place at the Gem and Frisco mines, yet only five men were killed. A side-light on these events is afforded by Charles A. Siringo, a detective hired by the Mine Owners Association. In his book, 'A Cowboy Detective', published in 1912, he relates his experiences during this strike. Acting under instructions, he played the part of a miner and joined the union at Gem. His reports were mailed to St. Paul, Minnesota, where a copy was made and sent to the secretary of the Mine Owners Association at Wallace. Siringo, or 'Allison', as he then called himself, was elected secretary of the union; whereupon he did the correct thing, shirked work, and was discharged. In order to remain secretary, he pretended that his father sent him money from Texas. The treasurer of his union was George A. Pettibone, a justice of the peace, later to be numbered among those who were punished for their crimes. With Pettibone and other union men he would order 'scabs', that is, those refusing to join the union, out of the country, and, if necessary, "get up a mob, by holding a citizens mass-meeting, to run them out of the State". Only members of the union were permitted to enter the "citizens' meeting". He describes

the sequel: "Then it would be declared the sense of the citizens indignation meeting that certain 'scabs' be run out of the State. Often as many as half a dozen 'scabs' would be taken from their homes, sometimes with weeping wives and children begging for mercy, and with tin pans and the music of bells, they would be marched up and down the street to be spit upon and branded as 'scabs' before the public eye. Then half-clothed and without food, the poor devils would be marched up the canyon, a few miles beyond Burke, and told to hit the road. Pistols would be fired over their heads to give them a good running start. By this route, during winter, the snow is waist deep over the Bitter Root range, and there is not a living inhabitant until Thompson's Falls, Montana is reached, a distance of about 30 miles. This thing was kept up all winter, and I learned a few new lessons in human nature". His reference is to the winter of 1891–1892.

When war was declared between the mine-owners and the miners unions in the spring of 1893, the sheriff of the county was friendly to the unions, of which fact Allison informed his employers; whereupon they arranged matters so that a trainload of strike-breakers passed through Wallace without stopping, thereby eluding the sheriff, who stood ready to arrest them under the State law against importing armed thugs. Each side invoked the law and both sides disregarded it. The conflict was a lawless fight, a reversion to frontier barbarism. Other trainloads of strike-breakers were imported under armed guards. Soon it became evident that the secrets of the Gem union were being given away by a traitor, so a Butte detective was put to work to spot him, and Allison's job became uncomfortable. He was charged with disloyalty at a meeting called for the purpose, but managed to bluff his accusers. Two days later he had reason to believe that he had been recognized by a man whom he had helped to convict in Nevada. It was time to skip. He hid under the sidewalk, and while there saw some of the fighting and heard the explosion at the Frisco mill. Crawling under the side-

walk, he escaped, while angry men overhead were discussing what they would do to him. He tells a good story. A few days later he was kept busy identifying the union leaders, who were arrested by the troops under General Carlin and placed in the 'bull-pen', a large stockade with a frame building in which the prisoners slept and ate. In less than a week 300 were placed in the 'bull-pen', which was at Wardner.

Work at the mines was resumed, the bad men were arrested or driven out of the district, and order was restored, but the feeling of bitter antagonism survived between union and non-union labor. Several outrages were committed, one of the worst being the murder of John Kneebone in July, 1894, and the expulsion by force out of the county of R. K. Neill and three other men. On April 23, 1899, a demand was made on the Bunker Hill company by the Wardner union for a uniform wage of $3·50 to all underground men and for the recognition of the union, now affiliated with the Western Federation of Miners. The new manager, Frederick Burbidge, said he would submit the matter to the other officers of the company; they agreed to increase wages of all laborers from $2·50 to $3·00 and of all miners from $3·00 to $3·50 per day, but refused to recognize the union. On April 26 the tramway was seized by a group of armed strikers and men were stopped from going to work.

On April 29 a group of masked men at Gem took possession of a train from Burke, they compelled the engineer to back the train to the powder-house at the Frisco mine, where 70 boxes of dynamite were loaded on a box-car. The train then went to Wallace. There a number of men from Mullan got on board. Proceeding to within a mile of Wardner, the engineer was compelled to stop the train while another group of men boarded it. By this time the mob on the train numbered about a thousand, of whom 300 were masked and armed. They left the train and went to the Bunker Hill mill, which was then completely destroyed by the use of several hundred pounds of dynamite.

As soon as the echoes of the explosion had died away among the surrounding mountains, an ominous silence ensued, to be broken by a deafening fusillade from the train, this being meant to celebrate the 'victory' of the ruffians posing as labor reformers. Nobody was killed at the mill, but during the excitement that followed John Smythe, a Frisco miner, was shot and killed; James Cheyne, a vanner-tender of the mill, was fatally wounded; and R. R. Rogers, stenographer with the Bunker Hill company, was wounded. Smythe is said to have been killed by the strikers because he was suspected of being a 'traitor'; for the killing of Cheyne, a man named Corcoran was convicted and sentenced to 17 years' imprisonment.

Those were bad days for the staff at the Bunker Hill. Wisely, they did not meet violence with more violence, for that would have settled nothing. Friends came from Gem to warn them of the impending danger; they were told that 500 men had stolen a train, opened the Frisco powder-house, broken into militia headquarters and seized rifles, and were coming down to blow up the mill. Word was passed for everybody to abandon the property and seek safety. W. C. Clark, the electrician, tells me that after he had seen "the mill go up" he noted the sun glistening on the dinner-buckets of a group of men on the hillside coming down from the mine toward Government gulch, so as to avoid Wardner. They were friends. The whole party, including the mill staff, then walked to the mouth of Pine creek, where they camped. J. C. Bodley, an old-timer, made 'biscuits' for them that night. They waited until 11 p.m., when a special train sent by the president of the company, F. W. Bradley, came up from Tekoa. At Cataldo they picked up Mr. Burbidge, who had escaped over the river flats. On arrival at Tekoa, at 5 a.m. next day, they breakfasted, and four hours later took the train back to Kellogg, where they learned that the strikers had gone and everything was quiet. The Kellogg adit was being driven at that time and the management was anxious not to suspend this particular work, so, as the power-plant had

been destroyed, the old plant in Milo gulch was brought into use and an Edison bi-polar dynamo was installed for driving the cars in the adit. Lights from the same dynamo were used to illuminate the bull-pen at Kellogg, where 500 men were imprisoned all summer. This is the second mention of a 'bull-pen'. Again United States troops were sent into the district, on appeal from the Governor of the State. General H. C. Merriam was in command. He 'rounded up' those suspected of complicity in the destruction of the mill and placed them in the bull-pen. Most of those charged with major offences escaped and those charged with minor offences were released, because the county declared itself unable to try so many persons. This illustrates the break-down of local government. Owing to complaints made against the harshness with which the prisoners were treated, this matter was referred by Congress, on January 8, 1900, to the Committee on Military Affairs for investigation. It was charged that there was issued and enforced by General Merriam a proclamation in violation of the Constitution of the United States and of the State of Idaho. The proclamation read as follows:

"Whereas the following notice has been served upon the mine-owners of Shoshone county by the duly constituted State authorities, by whom martial law has been declared, to-wit:

"To the mine-owners of Shoshone county:

"Certain organizations or combinations existing in Shoshone county have shown themselves to be criminal in purpose, inciting and, as organizations, procuring property to be destroyed and murders to be committed, by reason whereof it has been twice necessary to declare martial law in Shoshone county.

"You are therefore notified that the employment of men belonging to said or other criminal organizations during the continuance of martial law must cease. In case this direction is not observed your mines will be closed."

The effect of this proclamation, of course, was to prevent union men from obtaining work in the county, whereupon the

authorities, civil and military, were charged with "an outrageous misuse of the military power of the United States . . . in the interest of the owners of the Bunker Hill and Sullivan mines". After an investigation that lasted three months, the committee of Congress reported that none of the 'whereases' was sustained by the evidence, but a minority of seven condemned the action of the President, the Governor, and the General.

The trouble-makers were scattered effectively and normal conditions of production were restored by the end of the year.

The story of these labor troubles is an essential part of the history of the mines; the facts have been stated with an intentional impartiality, but possibly not without some prejudice in favor of the engineers in charge of the mines. It is true, the stockholder was receiving his dividend when wages were being reduced, and the capitalist seemed to be profiting at the very time when the miner's pay was cut, but the capitalist and the stockholder had to wait many years before they received any return on their money, the use of which, for developing the mines, involved a decided risk, a risk so large as to justify a proportionate financial reward. The miners, undoubtedly, were stimulated to strike and to disorder by a few professional agitators, without whom, probably, the managers could have come to reasonable terms with their employees. To the future historian, I think, the incapacity of local authorities to maintain order, and the consequent condition of real anarchy that supervened, will be the most surprising feature of these events. The hiring by the companies of ruffians in the guise of laborers, under the guard of detectives, to fight the corresponding ruffians on the other side is worthy of medieval days,[1] not of a modern republic devoted to liberal ideals. One other feature calling for comment is the hasty use of 'guns', meaning revolvers, in these mining-camps. The revolver is primarily a weapon of assassination, not of defence, and as used in these frontier disputes the use of it constitutes a blemish on our American

civilization. The 'gun' is practically unknown in the mining life of Australia or South Africa; it is peculiarly western American. The future historian is certain to comment on this fact; let us anticipate him, and tender our apology.

During these disorders the Bunker Hill suffered, as we have seen; the mill that the strikers destroyed in 1899 was replaced by another erected on the same site in 1900. In January, 1909, the mill treated 27,400 tons of ore assaying 14·2 per cent lead and 5·1 ounces silver per ton, the aggregate assay-value being $15·48 per ton, with lead at 4·5 cents per pound and silver at 53 cents per ounce. Another mill was built in 1909; it was designed by Gelasio Caetani on the basis of experience gained in the older mills. This Italian engineer was a graduate of the Columbia School of Mines, and, it may be added, the son of the Duke of Sermoneta. In 1924, as Prince Caetani, he served as Ambassador to the United States, after most distinguished service during the Great War. In June, 1919, the feed to the new mill assayed 10·05 per cent lead and 3·9 ounces silver per ton; the average assay of the resulting concentrate was 68 per cent lead and 23·8 ounces silver per ton. The economic extraction was 55·8 per cent for the 28,436 tons of ore treated.

A smelter was built near the mine in 1917 at a first cost of $2,500,000, which now has been increased to a total expenditure of $3,934,715. In 1918 the tonnage of ore that came from the mine was 389,027, at a total cost of $3·70 per ton. The milling cost was 71 cents; the smelting and refining per ton of concentrate was $12·74*; the operating profit was $6·45, and the dividends $3·99, per ton of ore. For the 33 years to the end of 1920 the total operating profit was $30,-627,610, to which profits from subsidiary mining companies amounting to $4,213,606 were added, making $34,841,216 in all. The dividends paid had aggregated $23,231,250, the cash and bonds in hand amounted to $2,383,933, leaving

* In 1930 the cost of smelting and refining, including depreciation, was $9·10 per ton of concentrate.

$9,226,033 as the sum spent in equipment, purchases of additional property, litigation, etc., in addition to the bare operating cost. During this period of 33 years the gross yield of the ore was used thus:

	Per Cent
Operating cost	25·30
Freight and treatment	41·21
Dividends and cash	28·01
Betterments and additional property	5·48
	100·00

In the 11 years 1920–1930 inclusive, the mine has yielded 4,835,010 tons of ore, from which 869,405 tons of concentrate has been made; from the concentrate 850,095,111 pounds of lead and 15,499,964 ounces of silver have been recovered. The cost of mining has averaged $3·84 and the cost of milling 94·5 cents, per ton. The operating profit during this period has been $28,492,440, from which dividends amounting to $24,584,237 have been distributed to the shareholders.*

The concentrate goes to the company's smelter. In 1929 the smelting cost per pound of lead was 3·01 cents out of a total production cost of 5·67 cents per pound of lead. In 1928 the electrolytic zinc-reduction plant, having a capacity of 65 tons of slab zinc per 24 hours, was started. This plant, named the Silver King, is the property of the Sullivan Mining Company, which owns the Star mine, at Wallace. The Sullivan company in turn is owned as to one-half by the Bunker Hill & Sullivan Mining & Concentrating Company and as to the other half by the Hecla Mining Company. The zinc produced by this plant is noted for its purity, 99·99 per cent, and for this reason commands a premium of $20 per ton even during the present period of depression. The cost of the plant was $3,500,000. The future historian will be interested to learn that the first slab of zinc was inscribed as follows:

* These figures I owe to the courtesy of the manager, Stanly A. Easton.

"First sixty pound slab of 99·99 per cent Bunker Hill zinc poured at the electrolytic zinc reduction plant of the Sullivan Mining Company, Tuesday afternoon, November 6th, A.D. 1928. Being the day upon which the Honorable Herbert Hoover was first elected President of the United States."

The aforesaid future historian will infer, correctly, a most friendly feeling on the part of the Bunker Hill manager for his fellow mining engineer at Washington, and he will note the word "first", which indicated a lively hope that Mr. Hoover might be re-elected in 1932. As to the correctness of this anticipation, the future historian will have an advantage, as he will have in a great many other ways, over the writer of this book.

It is interesting to note that the recovery of the zinc is due to the use of the flotation process. Formerly the zinc was discarded; indeed, not long ago all our western smelters exacted a penalty of 50 cents per unit on ores that contained over 8 or 10 per cent of zinc. Current penalties are usually 30 cents per unit over a free allowance varying from 7 to 10 per cent. Thus zinc at one time was a drug on the market; it was regarded as a nuisance by the metallurgist at the lead or copper smelter. Much of the zinc recovered today is a by-product that has become of economic worth simply by reason of the facility with which, by aid of froth flotation, a zinc concentrate can be recovered separately from a lead concentrate, both being derived from a complex ore. Of the six mills operated by the Bunker Hill company, only one is doing any gravity work, and even that one is supplemented by flotation; all the others are plants devoted to the use of flotation, which, in contrast to the old method of gravitation, may be said to be a process of levitation.

But technology and statistics do not tell all the story of a mine. A stockholder, at Chicago, talking about the ups and downs of life, remarked that when everything seemed to be going wrong with him he would turn in his chair and look up at a photograph on the wall showing the Bunker Hill

mine, and would then recall the fact that it had seemed likely to fail at times, yet the stock he held in the enterprise had provided for the clothing, the education, and helpful start in business of his children. The reminder always gave him a fresh impulse of courage to go ahead, and a renewal of confidence in the future. Such a mine as the Bunker Hill is more than a hole in the ground; it is an expression of hope, initiative, energy, and accomplishment; it is the fine flower of industrial achievement.

CHAPTER XV

THE GOLD, SILVER, AND COPPER OF BUTTE

The first discovery of gold in Montana is credited to François Finlay, a half-breed, from the Red River country, in Canada; he went to California during the early days and learned there how to wash the gold from placer deposits; then, on his return, he crossed Montana and found gold on the western slope of the Rocky Mountains, on Gold creek, a minor tributary of the Hell Gate river, in what is now Deer Lodge county. That was in 1852.* Finlay did not find enough gold to induce him to continue at work, but six years later a group of miners, led by the brothers James Stuart and Granville Stuart prospected on this same creek, obtaining about ten cents to the pan. They, however, were harassed by the Blackfeet Indians, and they were also handicapped by lack of proper tools; so they too desisted from further operations.

Two years later, in 1860, Henry Thomas started to work on Gold creek with three sluice-boxes hewn out of green timber that he cut on the spot. With this simple apparatus he won from $1·50 to $2·00 per day. This may be considered the first instance of systematic mining in Montana. Meanwhile the Stuarts went to Fort Bridger, in southwestern Wyoming, where they remained as traders until 1861, when, again lured by the gleam of gold, they returned to the valley of the Deer Lodge and resumed prospecting, using 10 sluice-boxes that were brought from Walla Walla, in Washington, 425 miles distant. In the summer of 1862 they were joined by many others, chiefly from Colorado, in consequence of an exchange of

* W. S. Keyes, in appendix to 'Reports on the Mineral Resources of the United States', p. 39; 1868.

letters, whereby the fact of their having found gold became known to many.

In 1862 John White found gold on Grasshopper creek, a tributary of the Beaverhead river on the eastern slope of the Bitter Root mountains. Soon afterward other rich bars were found, and in the fall of 1863 the town of Bannack was laid out. Here the first important mining operations in the State were begun, and with such success that the fame of the diggings attracted a large number of energetic men during 1863.* The placers of Bannack yielded about $4,000,000 in gold.

In the spring of 1863 a party of eight men led by William Fairweather went from Bannack to prospect in the Yellowstone country, eastward. They were attacked by the Crow Indians on the Gallatin river, but all save one of them managed to escape, with the loss, however, of all their provisions and most of their horses. When returning, worn with fatigue, they camped on the bank of a stream, which, of course, they examined for gold. Fairweather noticed a spot where the bedrock was exposed, and started to pan the loose earth, obtaining $1·75 of gold at the first trial. Other places were tested, with encouraging results, whereupon four of the party proceeded formally to stake their claims. This was Alder creek, now identified with the richest placer diggings ever developed in Montana. Not much could be done, on account of the lack of provisions, so they moved to Bannack, from which place they returned, accompanied by others, to the gulch along which they had made their locations on June 6, 1863. Within two years Alder gulch was the site of several settlements, including Virginia City, which had a population of ten thousand, and became the capital of the Territory of Montana in 1865, in succession to Bannack, which was the first capital.

Alder gulch proved to be extremely rich. At the head of the ravine, in the mountains, nine miles south of Virginia City, the gold was coarse, even nuggets worth $200 to $800 being

* W. A. Clark, 'Helena Directory', p. 21; 1884.

recovered. Lower down, below the town of Summit, the gold was in the form of flakes, rounded at the edge, and known therefore as 'scale' gold. Still lower in the gulch the precious metal became progressively finer until it was not only 'dust' but 'flour' gold. During the year of the discovery not much of the best ground was tapped, owing to the fact that the rich sediment lay so deep as to require a systematic scheme of

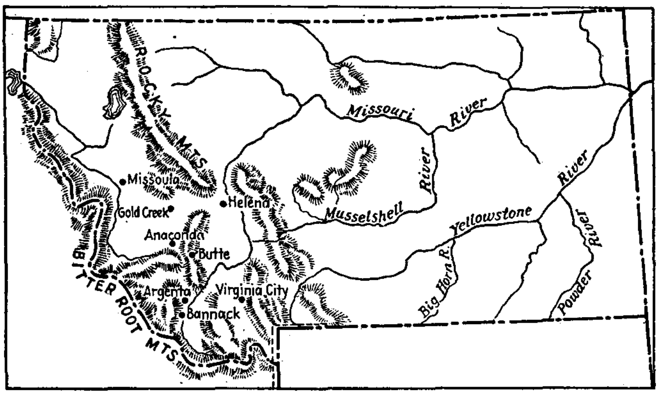


FIG. 25.—Map of Montana. (*Reproduction licensed—base material copyrighted by Rand McNally & Company.*)

bedrock drainage. In 1868 it was estimated that $30,000,000 had been taken out of Alder gulch.*

In September, 1864, gold was discovered in Dry gulch, much farther northward, and shortly afterward in Last Chance gulch, near-by, more gold was found. A group of 20 men set to work, and a little later a party of immigrants from Minnesota, on their way to Alder gulch, stopped to prospect in the adjacent ravines, in which they developed profitable diggings, notably at Grizzly and Oro Fino; but not until the following February, of 1865, did it become widely known that this rich placer district had been opened up. The locality is now

* J. Ross Browne, 'Reports on the Mineral Resources of the United States', p. 507; 1868.

identified with the site of Helena, which became the capital of the Territory of Montana in 1874; however, the early mining phase of the city's life is now almost forgotten, in consequence of the exhaustion of the alluvial diggings, in which only an occasional painstaking Chinaman can be found grubbing amid the tailings of pioneer days. It is interesting to note that as late as 1884 there was so much gold in the unworked portion of Main street, in Helena, that a contractor in payment for excavating the foundation of the building erected for the Montana National Bank was willing to accept the gravel that he dug out of the site.

In Montana, as elsewhere, the placer miner blazed the trail for the lode miner; indeed, widening the generalization, one may say that all over our western domain, as in other parts of the world, the finding of gold has been the first step in the development of a mining industry. Gold is found in its native state, and requires therefore no smelting or refining to prepare it for market. The extraction of gold from the gravel of the stream is the simplest process used by the miner; it can be performed with an apparatus of the crudest kind; and the results are evident forthwith. Gold is so valuable that the product of a placer mine is not bulky, and therefore can be carried or shipped by primitive means of transport. Everything unites to make gold-washing the pioneer phase of mining. In 1867 the yield of gold from Montana was $12,000,000. The placer diggings of Montana altogether yielded $150,000,000 up to 1876.

The first lode mining in Montana was done in the Bannack district, where, in 1862, two miners, named Allen and Arnold, built a stamp-mill.* It was entirely home-made; the iron was taken from old wagons and was fashioned by the blacksmith; much of the lumber also came from discarded vehicles. This mill had six stamps, each of 400 pounds, and was driven by water. The ore came from the discovery claim, named the

* H. H. Bancroft, 'History of Washington, Idaho, and Montana', p. 723; 1890.

Dakota. In the fall of 1864 another mill, actuated by steam power, was started at Bannack.

This mill was purchased by Hopkins and Butterfield at St. Louis and brought from there at a total cost of $25,000. It had 24 stamps, but only 12 were set up. Each stamp weighed 550 pounds, and dropped 14 inches at the rate of 45 times per minute. No gold-saving devices were used except amalgamating plates, and the mill is said to have saved only 25 per cent of the gold in the ore for the British owners of the mine, the No. 6 Dakota.

The placers of Alder gulch were enriched by the veins of Summit. The first quartzose ore from the hill claims (the best of which was the Oro Cache, discovered in 1864) was crushed in a stamp-mill that had a capacity of only 3½ tons per week. In 1868 several mills had been built; these crushed nearly a ton per stamp per day at a cost of $6·50 to $7·00 per ton. The mills themselves cost from $20,000 to $30,000 each, and had a capacity of 15 to 24 tons per day, from which we may infer that they had from 10 to 30 stamps. Wages were from $6 to $9 per shift.

The placers of Silver Bow, in the valley below the site of Butte, were discovered by Budd Parker, P. Allison, and the two brothers (Joseph and James) Esler, who came thither across the main range of the Rocky Mountains from Alder gulch in 1864. It is said, however, that Caleb Irvine, when crossing this valley as early as 1856, found evidence of "prehistoric" mining. Such statements are common in the chronicles of the pioneers, whether in Montana or in Michigan; they refer usually to holes dug by their predecessors of the same race and period, but abandoned prematurely by disappointed adventurers. In this case, as is customary, the "ancient" working was imputed to the aborigines, but we have no reason to believe that any Indian dug the prospect-hole that Irvine found on the hill now celebrated for its copper mines.

The news of discovery, as usual, caused a stampede from the nearest camps and brought a crowd of diggers, who soon

extended their operations up Silver Bow creek for five or six miles to Town gulch, where the houses of Butte now cluster. In February, 1865, Silver Bow was made the county seat of Deer Lodge county and for a short time it became even the capital of the Territory of Montana, which had been organized the year before, but its tenure of the honor was precarious, for in June the Democrats shifted the capital to the town of Deer Lodge. However, despite this loss of political prestige, Silver Bow continued to flourish, although the gold from the placers was of inferior quality, selling for only \$12·00 to \$14·00 per ounce, as against the \$16·50 to \$18·00 paid for the gold from the other gulches. The impurity of this gold, occasioned by an admixture of silver, should have suggested the fact that the alluvium had been enriched from the degradation of the outcrops of veins that contained both silver and gold, as the pale gold of the canyons at the foot of Mount Davidson presaged the discovery of the Comstock lode. At the base of the hill made famous by the Anaconda mine, there were excellent placers. They were close to the veins. Ross Browne wrote in 1867: "In every gulch where gold placer mines are found, gold-bearing quartz veins are found also, many of which contain silver, copper, antimony, arsenic, and manganese, and are rich but very refractory".* Such were the outcrops through which the miner had to penetrate in search of the great ore-bodies, rich in silver and copper, of the Butte district; but the significance of these signs was not understood by the diggers.

When alluvial mining was started on Silver Bow creek, the birth of Butte as a mining district was marked by a camp that was pitched on the hillside above the placer workings by William Allison and George Humphreys, who came from Virginia City in 1864. They, it is said, found a hole, four or five feet deep, in a vein known later as the Original. Near it were some elk-horns that had been used as gads.† This probably was the "prehistoric" working mentioned by Irvine.

* J. Ross Browne, *op. cit.*, p. 504.

† M. A. Leeson, 'History of Montana', p. 917; 1885.

Others came up the creek, and soon the richness of the placers attracted such a crowd of diggers as to warrant the organization of a mining district and the location of a town-site, in 1866, to which the name of Butte was given, in reference to the conical peak that rose above the pine-clad slope northwest of the camp. The year 1866 marked the culmination of placer mining in the district; the yield of gold began to decline, and by the end of 1867 the diggings were almost abandoned.

The first lode claim to be located on the hillsides of Butte was the Asteroid, which was staked by W. L. Farlin in the autumn of 1864.* This covered a portion of the blackened quartz of an outcrop that later was re-located as the Travona. Several other locations, including the Parrott, were made at this time, but the prospectors were looking only for a free-milling gold ore, they set no particular value on these manganese-stained silver-bearing veins, until later the news of the great developments on the Comstock lode began to stimulate a more intelligent curiosity.

Some encouragement was given by the discovery of rich silver ore in the Travona in 1865, and in the following year an arrastra was constructed by Charles Savage to treat ore from the Parrott claim, but the attempt proved a failure. Then a 10-stamp mill, known as the Continental, was brought from Stirling to treat the silver ore at Butte, but it also failed as a metallurgic venture. It is said that Dennis Leary and T. C. Porter tried to smelt some of the Parrott ore in a furnace that they constructed in 1867; but this likewise was a fiasco. Then a small shipment of rich ore was made to Swansea, in Wales, but the cost proved entirely prohibitive. The outlook was gloomy indeed, and the camp languished, although assessment work was done on a number of claims, including the Parrott, Original, Gray Eagle, and Mountain; and in some of these prospects the workings had been extended to a depth of as much as 150 feet in the course of timid exploration.

* Walter Harvey Weed, 'Geology and Ore Deposits of the Butte District, Montana', U. S. Geol. Survey, *Prof. Paper* No. 74, p. 18; 1912.

At this time, in 1867, there was a smelting-furnace in operation at Argenta, on Rattlesnake creek, north of Bannack. Silver-lead ores were being reduced by aid of charcoal as fuel. Evidently this venture provoked no confidence, for W. S. Keyes, commenting upon it, said that "ores containing less than $100 per ton cannot, in my judgment, be at present smelted with a profit". He was sure, despite his training at Freiberg, that it was all a mistake to use fire-reduction methods. "This much is certain", he remarked, "amalgamation is more expeditious and far cheaper; the one performs most of the labor by machinery, that is, is thoroughly in consonance with the spirit and genius of the people; the other necessitates repeated handlings and much manual labor, and hence its greater expensiveness." Comment is superfluous; the reader can make it himself in accordance with his own particular sense of humor.

No progress was being made, the outlook was gloomy, and the unhappy town was losing its scanty population when in 1875 William Farlin built the Dexter 10-stamp mill and furnace near the Travona mine, and began to treat the ore by means of a chloridizing roast followed by amalgamation, in the Freiberg style. It is said that Farlin took some samples of ore with him to Owyhee, in Idaho, where he had them assayed, and thereby learned that they were rich in silver, with some copper. At this time also he obtained information concerning the treatment of such an ore. This knowledge he kept to himself, having formed the intention to re-locate, or jump legally, some of the most promising claims on which assessment work had not been done. On the night of the last day of 1874 he placed his notices of location on the Travona and other claims that subsequently proved extremely valuable. Farlin's mill, however, was hardly a success until it was completed by W. A. Clark in 1876, at which date the profitable treatment of the silver ores of the district may be said to have commenced.

In 1878 the output of Butte was:

Silver bullion	$ 899,000
Gold-dust	85,000
Ore shipments by the Utah & Northern Railroad, 1920 tons Ore shipped by the Missouri river, 135 tons	190,000
	$1,174,000

The gold-dust indicates that some of the placer diggings were still productive. Alder gulch and the Last Chance diggings continued to give profitable employment to groups of old prospectors for several years longer.

The price asked for milling was $25 to $30 per ton; this was high enough to incite the building of more mills and to develop useful competition. In 1875 the shipment of some rich ore from a claim called the Acquisition to the Walker brothers at Salt Lake City caused these consignees to send Marcus Daly to examine the mines at Butte. He arrived in 1876, and soon took an option on the Alice mine for $5000. The reader will have noted the entry upon the stage, successively, of two of the chief actors in the economic melodrama that was to attract attention to Butte in later years. William A. Clark and Marcus Daly are names famous in the history of the American mining industry.

Daly commenced work on the Alice during the late summer of 1876, and in the following year, when the shaft had reached a depth of 200 feet, he brought an old 20-stamp mill from Ophir, Utah, and erected it on the Alice property. It was a dry-crushing plant, and was designed to treat oxidized ores, whereupon in 1878, he added a White-Howell roasting-furnace for the purpose of a chloridizing roast of the sulphidic silver-bearing ore. In 1880 a 60-stamp mill, with two White-Howell roasters and a drying-cylinder, was built by the Alice company. Then the Moulton and Bluebird mills were built after the same pattern. The climax of the silver period was reached in 1887 when the Alice mill had 80 stamps, the Moulton 40, the Lexington 50, the Bluebird 90, and the Silver Bow 30, a total of 290 stamps, treating altogether about 400 tons per day, for an average yield of $25 per ton in silver,

besides a little gold. The active operation of the silver mines had revived Butte, so that in 1880 the population was 3000; and on December 21 of the following year a railroad connection with Ogden was completed as far as Silver Bow junction.

The outcrops of the copper lodes were bare of vegetation, for chemical reasons, and therefore they were noticed by the earliest prospectors, some of whom made locations on them, such as the Parks, Parrott, Original, and Gagnon, even before the close of 1864. In the following year a shaft 40 feet deep had been sunk in the Parks vein and disclosed six feet of copper ore. In 1866 an attempt was made, as already recorded, to smelt some of the ore from the Parrott claim, and a year later another furnace, built of stone and provided with a bellows, had been put to work on the Washoe claim. This also failed. The mining of copper was long delayed for reasons by no means wholly metallurgic, for the establishment of a copper industry requires economic conditions, including railroad transport, much more highly developed than those sufficient for successful gold-mining, or even for silver-mining. To Clark and to Daly belongs much of the credit for making the copper mines successful. In 1872 Clark turned his attention to the matter, and in 1873 he began to develop the Colusa, Original, Gambetta, and Mountain Chief mines. The ore they yielded was hauled in wagons 400 miles to Corinne, in Utah, the nearest railroad point, from which it was shipped to various buyers, one of these being the Boston & Colorado Smelting Company, at Blackhawk, in Colorado. To the directors of this company, notably Nathaniel P. Hill and Richard Pearce, Clark suggested the building of a custom smelter at Butte. This was in 1878. Henry Williams was sent to investigate the conditions, and when he reported favorably the Colorado & Montana Smelting Company was organized, in 1879. Forthwith a smelter was erected at Butte, thereby establishing a local market for both the silver and the copper ores of the district. This was a critical event. The need for such a local smelter can be inferred from the fact,

as Weed* states, that a shipment of 35 per cent copper ore from the Green Mountain mine to the refinery at Baltimore, in Maryland, in 1877, *yielded no profit although it contained* $130 per ton in copper and $50 per ton in the precious metals. The arsenic in the ore served to excuse a high charge for treatment, which, with the cost of transport across country, overwhelmed the assay-value. The Colorado & Montana Smelting Company, in which Hill and Pearce joined hands with Clark, leased several silver mines and used their manganiferous ore to mix with the custom copper ores, thereby producing a high-grade matte that was sent for refining to the Argo works at Denver.

We have seen how Daly, convinced of the favorable prospects of mining at Butte, persuaded Haggin, Tevis, and Hearst to purchase the Anaconda in 1881. It was a small silver mine, only 60 feet deep, and the price was $30,000. At that time James B. Haggin and Lloyd Tevis were lawyers, in partnership, at San Francisco. George Hearst, the father of a well-known publisher and subsequently United States Senator from California, was a young man with a reputation for "a keen nose for ore". He had made a start by buying Osborn's interest in the Ophir, one of the discovery claims on the Comstock lode, and in 1872 he had advised his associates to purchase the Ontario, which proved to be the richest silver mine in Utah. In 1876 the same trio acquired the Homestake, in South Dakota. It is a remarkable fact that this group of enterprising men should have happened to select three of the best mines in the United States: the Ontario, the Anaconda, and the Homestake.

In 1881 Daly leased the Dexter mill for the Anaconda Silver Mining Company and treated 8000 tons of oxidized silver ore from the Anaconda mine, obtaining 30 ounces of silver per ton. This ore contained just enough copper to obviate the need for adding bluestone in the process of amalgamation, but the bullion was base, some of it running only 400 fine. Shortly

* Walter Harvey Weed, *op. cit.*, p. 20.

thereafter a seam of copper glance a few inches thick was cut at a depth of 100 feet, and this discovery stimulated further search for copper. George Hearst visited the district in 1882 and recommended deep development, for which he selected the place of a new shaft. A crosscut from this shaft, at a depth of 300 feet, penetrated 5 feet of copper glance, which was mined and shipped to Swansea. This shipment signalized the birth of the copper industry of Butte. A few years afterward a number of smelters were started in the district and the local reduction of the ores rendered unnecessary any further shipments to Wales. Matte was made, to be forwarded to the copper refineries on the Atlantic coast. Thus the copper industry of Butte was established. Meanwhile, at the end of 1881, the Utah & Northern railroad had connected the district with the main line of the Union Pacific at Ogden. Seven years later the Montana Central railway reached Butte, and in 1893, the Northern Pacific railroad.

Silver-mining continued to be important even after the copper resources of the district were tapped, until 1893, when Butte, in common with all the silver-producing centres, was prostrated by the collapse of the silver market. One or two mines, such as the Nettie and Lexington, remained active until 1897, and others have been revived at intervals since then, but none of the silver properties was a noteworthy producer in later years except the Lexington, which yielded silver ore that contained copper also. Thus Butte passed through three stages of development, devoted to the winning of gold, silver, and copper in turn. In 1895 the Anaconda company was reorganized as the Anaconda Copper Mining Company, with a capital of 1,200,000 shares of a par value of $25 apiece. A large block of stock was placed in London, but most of it drifted back to the United States, because the enterprise was not properly appreciated in England. The organization of the Amalgamated Copper Company in 1899 was the prelude to an enormous consolidation of properties under the domination of capitalists identified with the Standard Oil

Company, one of the most powerful and profitable industrial organizations in the world. H. H. Rogers more particularly became prominent in Amalgamated affairs. First the Washoe, Colorado, Parrott, and Anaconda companies, owning various mills and smelters, were joined under one control, and then in 1901 the Amalgamated acquired the Butte & Boston and the Boston & Montana properties. From 1884 to 1898, a period of 14 years, the Anaconda yielded 9,575,793 tons of ore that averaged 5½ per cent copper, 4½ ounces of silver, and 35 cents in gold per ton. In 1900 the Amalgamated company produced 1,421,500 tons, yielding $18,730,131, of which $5,365,518 was profit.

The growth of the Butte mining industry is shown by the following record:

Date	Gold, ounces	Silver, ounces	Copper, pounds
1882	12,094	2,699,296	9,058,284
1887	48,175	6,958,981	78,699,677
1892	36,223	8,311,130	163,206,128
1902	46,051	10,106,884	288,903,820
1909	39,443	10,609,328	311,323,650

It will be noted that the copper ore continued to be enriched by gold and silver; this suggests, what was a fact, that the precious metals obtained from the quartzose ore in the shallow workings represented the upper portion of veins that had been weathered and leached.

From 1882 to 1884 the Anaconda company shipped 37,000 tons of ore, averaging 45 per cent copper, from Butte to Swansea. In 1883 Daly decided to build a smelter for the company near Warm Springs creek in the Deer Lodge valley 26 miles from Butte. The site was chosen on account of the abundant supply of water. The first plant, on the north side of the creek, was designed to treat 500 tons daily, by concentration and smelting; it began to operate in September, 1884.

The ore treated at Anaconda for the first few years averaged 12 per cent in copper; this was concentrated mechanically and then smelted into a 64 per cent matte, which was sent to Swansea and to Baltimore, until converters were added to the reduction works in 1892. Additions and reconstructions were made at intervals under the direction of Otto Stallmann until the plant was able to treat 1000 tons daily. However, this was not enough, so, in 1887, the construction of the Lower Works, as they were called, was begun on a site about a mile east from the first plant. Fire and other mischances hindered the completion of the new smelter, which was treating 3000 tons daily in 1889. According to Horace J. Stevens, an unprejudiced commentator, the management of the Anaconda in those days was unwise in the continued use of smelting-plants that were out of date. The old smelter became a heterogeneous collection of furnaces and mills that had grown without plan or system. However, this fact appears to have been realized, for, in 1898 Daly decided to build an entirely new reduction works on the south side of the creek. It was designed to treat 4800 tons daily, commencing in 1900, but it was soon enlarged to a capacity of 12,000 tons. This plant was designed by Frank Klepetko, but it was modified and completed by Edward P. Mathewson, whose long and successful career as manager of this justly celebrated copper smelter is a notable part of Montanan history.

Here a brief review of the development of smelter design may be of interest to the later historian. In the Colorado smelter, started by Henry Williams in 1879, the ore was roasted in a reverberatory furnace (50 by 12 feet) and then smelted in another reverberatory (14½ by 9 feet), by use of wood fuel. This smelting-furnace treated 12 tons of ore per day and produced a 60 per cent matte in which there was from 700 to 800 ounces of silver per ton.* The matte was hauled 200 miles to the nearest railroad. In 1889 the Bruckner cylinder

* H. O. Hofman, *Trans.* Amer. Inst. Min. and Met. Eng., Vol. XXXIV, p. 259.

was introduced for roasting, and in 1892 the Pearce turret-furnace was adopted.

In 1880 A. Wartenweiler started the Colusa smelter of the Montana Copper Company with four reverberatory roasters (60 by 11½ feet) and two reverberatory matte-furnaces (15¾ by 10 feet). The lump ore was roasted in heaps at first, but in 1882 the smoke nuisance was so great as to compel the use of stalls. This smelter was sold to the Boston & Montana Copper Company in 1888.

The Parrott smelter was completed in 1881; the ore was roasted in 11 reverberatory furnaces (60 by 14 feet) and smelted in 6 reverberatory matte-furnaces (14 by 11½ feet). The smelting charge was 2½ tons and the capacity of the furnace was 10 tons per day. The matte contained 60 to 67 per cent of copper, and 40 to 45 ounces of silver per ton; it was turned into blister copper, but this proved to be too expensive; indeed, the matte was marketed more easily than the blister copper. In 1884 a Herreshoff 48-inch water-jacketed blast-furnace was built by Edward D. Peters, the author of a standard textbook on copper-smelting, and in the same year the converting of the matte was begun under the direction of the inventor of the process, Pierre Manhès.

The upper works of the Anaconda company were started by Marcus Daly in 1883 with 34 reverberatory hearths (50 by 14 feet) for roasting the ore, followed by 26 matte-furnaces (20 by 14 feet) and two 70-ton water-jacketed blast-furnaces. The smelting charge in the reverberatory furnaces weighed 3½ tons, and 15 tons of roasted ore was smelted in each furnace in 24 hours. After the plant was destroyed by fire in 1889, it was re-built, unchanged in its design, until it was closed down early in 1902, when the new smelter came into operation. At that time the re-built plant contained 40 Bruckner roasting-cylinders (18 by 9 feet); 4 MacDougall roasting-furnaces (16 feet in diameter and 21 feet high) with 6 hearths, also 4 Wethey calciners, with hearths of 100 by 12 feet; and 11 reverberatory furnaces (31 by 16 feet) for treating the

matte. Each of these last took a charge of 9 tons and smelted 90 tons per diem. The lower works at Anaconda, erected two miles below the old plant, were designed by Otto Stallmann and started into action in December, 1888, with 56 Bruckner cylinders (18 by 9½ feet) and 28 reverberatory matte-furnaces (22 by 16 feet). Each of the latter took a 6-ton charge and smelted 40 tons in 24 hours. The old smelter building was destroyed by fire in March, 1889, and was replaced promptly by a steel structure. In 1890 the plant contained 40 Bruckner roasters, and in 1899 four MacDougall furnaces were added. The matte-furnaces were enlarged, four of them to 35 by 18 feet. These took an 11-ton charge and treated 75 tons daily. The converter plant was started in 1890 with 15 stalls for upright vessels, 10 feet high and 6 feet in diameter. Under the same roof were 6 blast-furnaces, 8 by 3½ feet at the tuyeres and 10 feet high. An electrolytic refinery went into operation in 1894.

The next plant, designed by Frank Klepetko, was started in 1902; it contained 48 six-hearth MacDougall roasting-furnaces, 16 feet in diameter and 21 feet high, together with five blast-furnaces 180 by 56 inches at the tuyeres and 15 feet high; also 14 matte-furnaces (50 by 20 feet) and 8 converter-stands (barrels, 12½ feet long by 8 feet in diameter). The farmers in the Deer Lodge valley began to complain of the ill effects of the smelter fume, whereupon a high stack and a long dust-chamber were constructed in 1903.

Butte produced three chromatic characters, Clark, Daly, and Heinze, an American of British origin, an Irishman from Ireland, and a German Jew from New York. Of the three, William Andrews Clark was the most successful and the most influential. He was born in Pennsylvania in 1839 and spent his boyhood on a farm. When his parents moved to Iowa, he went to school so effectively as to become a teacher. The devastation due to the Civil War caused him to migrate westward to Colorado, where he worked in the gold mines of Gilpin county. In his early manhood he experienced all the

trials and privations of frontier life. When twenty-four years of age, he went to the placer diggings of Bannack; with his gains he started a store at Virginia City, Montana, and later in Last Chance gulch, now Helena. In 1866 he went on horseback to the Pacific coast and bought a stock of goods with which he started business afresh at Elk City, and a year later he obtained the contract for carrying mail between Missoula, Montana, and Walla Walla, Washington. Evidently he was active and enterprising. He became wealthy, and with two friends he established banks at Deer Lodge in 1870 and at Butte in 1877. He was now a resourceful capitalist. In 1872 he bought a number of mining claims; and many others came into his hands as unliquidated collateral for bank loans. He then went to the Columbia School of Mines for a year of study. He was eager to equip himself for the control of large mining operations. Upon his return to Butte he organized the Colorado & Montana Smelting Co. and thereupon built the first smelter in the Butte district. Later he built the bigger plant of the Butte Reduction Works and acquired the rich Elm Orlu mine. Daly and he had been friends, but both being Democrats and both being determined to control their party, they became keen rivals and then implacable enemies. Daly had established his smelter at Anaconda, which he desired to make the capital of the State; Clark was willing to further this plan if Daly would support his candidacy for the United States senatorship, but they could not agree, whereupon Clark gave his support to Helena, which was eventually chosen as the capital. The reader will have noticed that Montana had five different capitals at intervals. In 1901, Clark, who was aided by Heinze, was elected to the United States Senate without opposition. Meanwhile he had become enormously wealthy not only through his mining operations in Montana but by the fortunate purchase and development of the richest copper mine in the world, the United Verde, in Arizona. Unlike most of the western mining millionaires, W. A. Clark was refined, even fastidious, but his intellectual

and artistic dreams were subordinated to a wide-awake and coldly practical activity in financial and political affairs; he was vain and liked flattery, but he was self-reliant and independent; he had a taste for good pictures and was a connoisseur of good wines; he was an accomplished man, and he accomplished much. He lived to be eighty-six years old.

Marcus Daly was of an entirely different type. Born of poor and illiterate parents, in Ireland, he came to the United States at the age of 15, and worked as a dock hand in Brooklyn, before saving enough money to pay for his passage to California and the gold mines. At first only a pick-and-shovel man, he soon acquired a good knowledge of mining practice. He worked for Mackay and Fair in the mines of the Comstock, where he attracted the friendly notice of the Walker brothers, by whom he was employed in Utah and by whom he was sent to Butte in 1876, when he was thirty-five years old. By working as a miner in the Alice mine he obtained the information on which he advised the Walkers to purchase it, obtaining for himself an interest, which he soon sold for $30,000. Shortly thereafter he severed his connection with the Walker brothers. Daly had become convinced that the mines of Butte were destined to be highly productive, so he went to San Francisco to solicit the aid of George Hearst, Lloyd Tevis, and James B. Haggin; they bought the Anaconda. At a shallow depth the ore became poor in silver but rich in copper, whereupon Daly stopped work and began to buy the adjacent claims, preparatory to a large-scale development. He acquired coal-lands to obtain fuel and huge tracts of timber-land to supply him with wood for the mines. He built a smelter at Anaconda and connected it with Butte by rail. He established banks, built power-plants, and started systems of irrigation. He was vibrant with energy and initiative. His feud with Clark debauched the political life of Montana from 1888 to 1900, when he died. He and Clark had been friends, but their interests clashed, and their characters were too unsympathetic to permit of a friendly adjustment. So the arena was set for a

virulent fight. Clark had control of the Butte Reduction Works, a custom plant, whereupon Daly built the Anaconda smelter, a few miles distant. Daly started the 'Anaconda Standard' and made it the best paper in Montana. Clark bought and directed a rival newspaper, the 'Butte Miner'. Daly's affable disposition, combined with a reputation for loyalty and courage, made him more attractive to the crowd than his reserved and astute rival. He was a born leader of men. Uneducated in a school sense and rough in his manners, Daly never sought office for himself, but placed his henchmen where they could be of use to him. For 10 years he thwarted Clark in his ambition to be senator, and even when his rival was first elected in 1899 Daly continued the vendetta by giving $25,000 to wage a fight in Washington whereby the new senator was compelled to resign. Daly spent more than half a million dollars in his effort to make Anaconda the capital, and in 1896 he gave $50,000 to the Bryan campaign fund. His career exemplifies the chances open to an energetic and resourceful man in the early days of the West.

The third celebrity of Butte was Frederick Augustus Heinze, a New Yorker of German-Irish parentage and Semitic ancestry. He graduated from the Columbia School of Mines in 1889, at the age of twenty-two, and immediately went to Butte, where, by the aid of Leonard Lewisohn, he obtained an appointment on the surveying staff of the Boston & Montana Copper Company, and thus had access to the maps of the district, thereby gaining a knowledge concerning unpatented fractions of which he made sinister use later. Not relishing drudgery of any kind and apparently slothful, he looked around for a livelier job. He left Butte and returned to New York, where he joined the editorial staff of the 'Engineering & Mining Journal', for one year. Genial, handsome, well-dressed, Fritz Heinze was liked by his associates, but he showed no aptitude for hard work and disliked any task that was confining. At this time his father died, leaving him some money. As soon as he obtained his share of the inheritance he returned to Butte

with the avowed purpose of starting a custom-smelting business. In 1892 he organized the Montana Ore Purchasing Company, and in an incredibly short time the furnaces were erected and put to work. He made money fast. As an adjunct to this business he leased several mines, and when directing their operations he became keenly aware again of the complexity of the vein system at Butte and the consequent conflict of apex rights. He began to purchase claims and fractions of claims that seemed to promise strategic advantage, including the Rarus, Johnstone, Cora, and Tramway. Meanwhile he went across the northern border into British Columbia and built a smelter at Trail to treat the ore from the Rossland mines. To assist this enterprise he built a railroad that connected the mines with the smelter. He also started a newspaper, 'The Miner', at Rossland. These ventures came to a fruitful end when the Canadian Pacific Railway Company bought him out—smelter, railroad, and newspaper—for a sum that was said to have been $1,200,000.

During the period of this Canadian excursion Heinze had retained his headquarters at Butte and had become involved in several lawsuits over mining rights, in which litigation he was assisted by clever lieutenants, legal, technical, and political, especially the last, because justice and legislation, like kissing, went by favor in those spacious days of the State of Montana. When the Amalgamated Copper Company was formed, the litigation between Heinze and its constituent companies reached a climax. Heinze posed as a David fighting against the Goliath of the Standard Oil Company, which, as represented by H. H. Rogers, was supposed to control the Amalgamated. The battle was joined with fearsome intensity; no weapon was left unused: trickery, bribery, and even bloodshed served the antagonists. Fortunes were made by the lawyers and handsome fees were paid to the experts that gave the scientific testimony needed in these apex suits, but one good result ensued, in so far as knowledge of the local geology was quickened by the evidence given in the courts and by the

disputes that arose therefrom. In 1902 Heinze transferred his interests to the United Copper Company and prepared to sell out. Through the friendly offices of Thomas F. Cole and John D. Ryan a settlement was made with the directors of the Amalgamated, who were tired of the costly imbroglio. Most of Heinze's holdings were purchased for the sum, so it was said, of $10,000,000. Thus in 10 years he had won a big fortune.

He returned to New York and engaged in banking business. In 1907 he started to corner United Copper shares, this stock being used as a gambling medium. The attempt failed, the stock exchange firm he had organized for his two brothers also failed, and he had to resign the presidency of his bank, the Mercantile National. That started the panic of 1907. An investigation followed, Heinze was indicted, to be acquitted after a long trial. There was joy in Butte, where he was popular, and to which he then returned, no longer buoyant. He had saved some of the wreckage of his fortune; with the Stewart mine in Idaho and the Mascotte in Utah he still did fairly well, but his last years were embittered by litigation arising out of his New York banking entanglements, and he died in 1914, at the pathetically early age of forty-two.

The people of Montana, like those of our other mining regions, had trouble with the Indians, simply because the prospector entered the hunting grounds of the aborigines, and they resented the intrusion. In 1877 Joseph, a chief of the Nez Percés went on the warpath, and it was W. A. Clark that rode, like a Paul Revere, 42 miles in less than three and a half hours, from Deer Lodge to Butte, to warn the mining community; and it was he, as Major Clark, that led the Butte battalion against the redskins. Chief Joseph had invaded Montana from Idaho and had marched to Missoula, pursued by regular troops under General Howard. Clark led his battalion to the aid of the citizens of Missoula, but the Indians avoided the town, and ten days later in the Bitter Root Mountains Chief Joseph and his men encountered a force commanded by General John Gibbons, by whom they were crushed in the

battle of the Big Hole. Clark brought one of his companies to the aid of General Gibbons and won high commendation for his services.

When Marcus Daly and W. A. Clark were waging their cat-and-dog fight for supremacy in the politics of Montana, and while the whole State reeked with the corruption inevitable from the reckless use of money on both sides, there entered the arena of Butte the young man from New York, Fritz Heinze. He gave a lurid touch to the hectic life of the mining centre, as we have seen. Ingenious and unscrupulous, he had become keenly aware of the entanglements of ownership caused by the careless locating of claims, of varying size and direction, in early days, and of the complications incidental thereto. The vein system of the district is intricate, and the dislocations due to faults have greatly increased the complexity of structure underground, producing conditions that completely stultify the so-called law of the apex. Heinze found ample scope for predatory litigation, and by means of a few well-selected purchases of claims he started lawsuits that undermined the ownership of some of the richest properties. When he was quieted at length, after a harassing conflict, costly in money and morale, there followed a long series of litigations of a similar type between the companies that owned mines in which were copper veins that trangressed the cryptic boundaries provided by an enigmatic law. Those were great days in Butte, 30 years ago, when the court was in session, and the stage was set for a performance the playing of which involved the gain or loss of millions of dollars. Lawyers celebrated for their forensic skill and geologists honored for their scientific knowledge were to be seen and heard as they played their parts. To those of the passing generation the names of the participants in these trials will revive poignant memories. Among the geologists in the case between the Anaconda and the Colusa-Parrott companies were Clarence King, founder of the United States Geological Survey; Nathaniel Shaler, professor of geology at Harvard; Rossiter W. Raymond,

secretary of the American Institute of Mining Engineers; David W. Brunton, one of the best mining engineers our profession ever produced; Frank L. Sizer, happily still honorably active in San Francisco; W. S. Keyes, a Freiberg graduate, who had had charge of the first smelter, the Argenta, in Montana; and Horace V. Winchell, geologist to the Anaconda company. Many of the lawyers came from Denver, notably Charles S. Thomas, Charles J. Hughes, and Joel F. Vaile. The future historian will be surprised to learn that the testimony in these lawsuits over apex rights came from scientific men in the generous pay of the litigants, and if he is sagacious, as future historians are supposed to be, he will marvel why the Court itself was not empowered to engage the scientific gentlemen in an advisory capacity, thereby freeing them from bias. The spectacle of a group of learned and honorable men testifying as to facts and theories in a sense opposite to that of the statements of another group equally learned and honorable will provoke a cynical smile from the aforesaid historian. As most of the cases were tried in the Federal courts, the Judges were men of high character, and there is no reason to believe that they would have abused the power, had it been given them, of selecting the specialists upon whom they could rely for a strictly scientific interpretation of the structural conditions to be observed in the ground concerning which the litigants were disputing. One or two incidents may be cited for the purpose of illustration. William Scallon, attorney for the Anaconda, asked O. A. Palmer, a witness for the Colusa-Parrott, if he recognized the existence of the Blue Lode. The witness replied: "I do not; I recognize the existence of stopes on the line of what you call the Blue Lode". As stopes are excavations in ore, the stopes in question were either in a lode or they were made to create the appearance of excavations in ore. The Blue vein, an ore-bearing fault-fissure, owed its name to the fact that it happened to be colored blue on the map prepared by the draughtsman in Clark's office. One group of 'experts'—they functioned

as expert witnesses rather than as expert scientists—was positive that the Anaconda crossed the Colusa, whereas the group on the opposite side was equally positive that the two veins joined. One side testified that there was a continuous Blue vein, which faulted both the Colusa-Parrott and the Anaconda veins, whereas the other side insisted that there was no such thing as this Blue vein and that the other veins were not cut off by it. Keyes had read a passage in Kemp's book on ore deposits. Whereupon Thomas asked him if he considered the book a standard authority. Keyes acquiesced promptly. Then Thomas read a passage from a later edition of the same book and "completely nonplussed" the witness, as a newspaper account tells us. The author, Professor Kemp, beloved as teacher and honored as scientist, had seen reason to modify his earlier description of some feature in the local geology, having obtained fresh evidence on the matter. This only suggests that when witnesses posed as consultants to a Wise Providence in the creation of the ore deposits, they were over-stepping the limitations of science; and it also suggests that no certainty was warranted on the part of such witnesses in swearing that a particular geologic structure could be interpreted in but one way, which was the way that favored the contention of the litigant by whom they were engaged, not as scientific witnesses but as hired advocates. Our future historian will find even more to say concerning these apex litigations. For the present it only remains to remark that although the work done in connection with the lawsuits did undoubtedly assist the mine-managers in understanding the vein structure of the Butte district, it is a significant fact that the interesting evidence given by geologists so positively in the courts is not quoted in any geologic treatise or in any scientific discussion, for the simple reason that it is suspect.

CHAPTER XVI

THE U.V.X., A MINING ADVENTURE

In the history of American mining, so far as I know, there is no cleaner, brighter, or more completely successful mining adventure than that of the United Verde Extension.* It deserves to be placed on record here.

The mine is at Jerome, 25 miles northeast of Prescott, in Yavapai county, Arizona. For 30 years before the U.V.X., as it is known to mining men, achieved celebrity, the Jerome district was identified with a copper mine, the United Verde, one of the great mines of the world. The success of this mine, of course, stimulated the search for similar orebodies, or for an extension of those already known, in adjacent ground; but, despite vigorous prospecting, the United Verde remained for many years alone in its glory. The reason for this solitariness was geologic: a fault with a big throw frustrated the effort to trace the ore-zone, thereby causing exploratory work to be both uncertain and costly.

Despite these failures to develop other mines in the vicinity, the belief persisted that all the ore was not localized in the United Verde mine, but before we consider the reasons for such a belief we must look at the geologic conditions. The basal rock of the Jerome district is a schist, which has been correlated with the Yavapai formation of the Bradshaw quadrangle. This schist is geologically ancient, for it is of pre-Cambrian age. It is composed of volcanic tuffs, together with sediments, both argillaceous and siliceous, all of which

* T. A. Rickard, *Engineering and Mining Journal*, June 14, 1924; also, by same writer, *Mining and Scientific Press*, January 5 and January 12, 1918.

have been so thoroughly metamorphosed that they are now difficult to distinguish from the igneous rock, diorite, that has pushed its way into them from a batholith, or deep-seated core of magma, the true character of which has been studied in the Bradshaw mountains, near Prescott.* The batholith is granite, its marginal phase is diorite, and the later offshoots are quartz-porphyry. The diorite has intruded so intensively into the basal rocks that it constitutes a large part of that complex formation; this has had the effect, increased by earth movements, due to crustal unrest, of bending the former layers of tuff and sediment into sharp folds and of shearing them so that now they appear as a schist. Moreover, by further metamorphism, caused by heat and pressure, the schist has become partly crystalline, and by later shearing movements the diorite has become partly schistose, so that today it is difficult to distinguish between them, except by careful examination under the microscope. To avoid precision, some of the geologists use the old-fashioned term 'greenstone' in speaking of this rock.

This pre-Cambrian complex was eroded by weathering until its surface was reduced to a peneplain, and on this base-level was deposited, from the Cambrian sea, the sediment that as sandstone now rests on the schist; and later, in the Devonian and Carboniferous periods, the sandstone was overlain by beds of limestone and sandstone. This later series of rocks, together with those on which they were deposited, underwent movement in places sufficiently violent to cause breaks through which came intrusions of the magma underneath, now appearing as dikes of andesite. Finally, the eroded surface of the later sedimentary rocks and of the old complex was smothered under flows of lava, extruded from numerous vents during the Tertiary period. This lava is a basalt that is known in the Southwest as 'malapai', a word derived from the Spanish *mal*, 'bad', and *pais*, 'land'.

* T. A. Jaggar, Jr., and Charles Palache, U. S. Geol. Survey, *Bradshaw Mountains Folio*, p. 4; 1905.

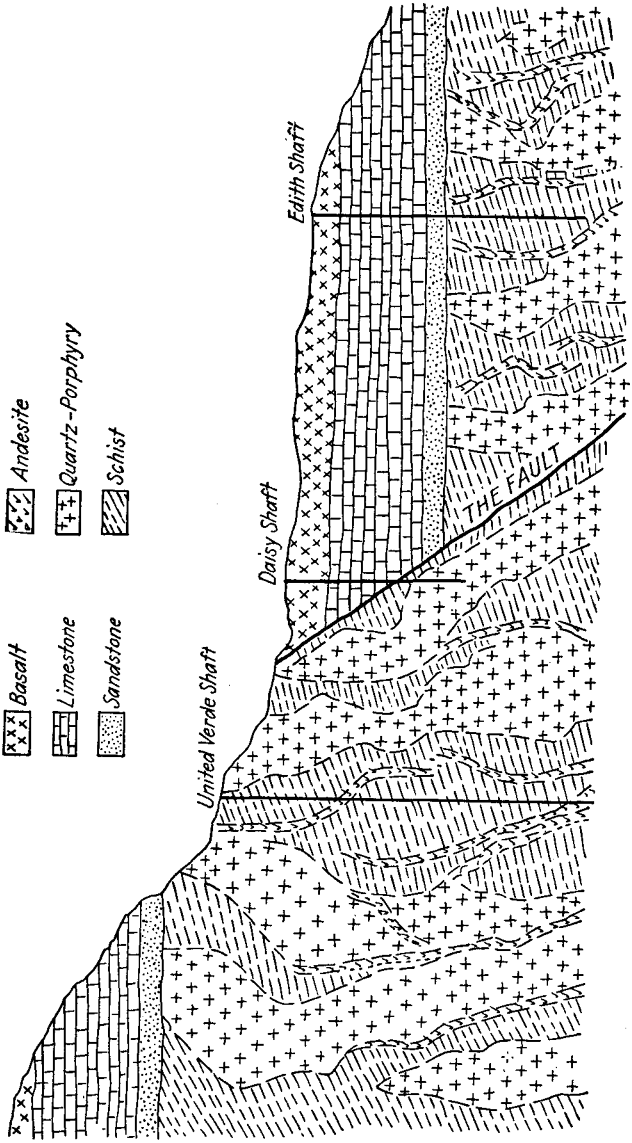


FIG. 26.—Geological section of the Jerome district.

Such are the rocks of the Jerome district. If one stands by the Douglas house on the ridge near the main shaft of the U.V.X., one can distinguish the various formations without difficulty. The slope of the mountain behind the town is an escarpment, the top of which is a plateau 7700 feet above sea-level, and at the foot of the mountain is the valley of the Verde river, only 3200 feet above the sea. The plateau is covered by lava. Facing this escarpment one can see the big open-cut of the United Verde mine; above it, on the sky line, are the horizontal beds of light-colored limestone; underneath them are the strata of reddish sandstone, resting on the schist. In front, in a gully that leads down from the United Verde, is more schist, but to the near right, northward, is a ridge of dark lava, under which are exposed the limestone and the sandstone, in sequence as above, and lying on the schist. These beds are far below the similar beds to be seen near the top of the mountain.

Obviously we have the evidence of a fault, which has dropped the entire series of rocks, from lava to schist, and has thereby dislocated the ore-bearing zone of the United Verde by many hundred feet. The fault can be seen and the line of it can be followed athwart the slope of the mountain from below the United Verde slag dump to the Jerome post-office, and much farther southward and northward from these points. It appears as a belt of broken rock, with bands of clay, dipping with the hill, northeastward, at an angle of 60 degrees. For several miles its general course is N53°W. It has a slightly corrugated surface, and may be regarded as a comparatively simple plane of movement. The vertical displacement caused by this fault is 1600 feet, and the horizontal displacement is 900 feet. Underground the fault appears as 180 feet of sheer-zone, within which is a series of minor step-faults, so that the drop between the two walls of the fault is about two hundred feet.

The United Verde orebody was found along the contact of quartz-porphyry and diorite where the latter had broken

into the schist, a short distance west of the fault. The ore-body is crossed by the fault, in consequence of which some of the ore at surface was scattered over the face of the mountain and thereby gave an incentive to prospecting.

Such are the geologic conditions, a general knowledge of which was common to well-informed persons in the Jerome district at the time when a search for ore in the faulted ground below the United Verde was started. The first to do so was George W. Hull, who, in 1899, organized a company named the United Verde Extension Gold, Silver & Copper Mining Company, which became known as the U.V.X.; and its successors, despite various slight modification of the registered name, have shared the use of this convenient abbreviation. This first company owned a dozen claims adjoining the United Verde property on three sides.

In March, 1899, Louis E. Whicher, of Boston, became interested in the U.V.X. enterprise to such an extent that he and his friends acquired control. A working capital of $100,000 was provided and a shaft was sunk. This shaft was within a stone's throw of the United Verde shaft and above the fault. It failed to find ore. At this time, in 1900, a surveyor named J. J. Fisher located a fractional claim of a little less than an acre between the United Verde and the March claim, also belonging to Hull. Fisher named his fraction the Little Daisy, and persuaded Whicher to provide money for sinking a shaft. This shaft was sunk 300 feet through the lava, limestone, and sandstone that covered the ore-bearing formation, which, as we have seen, is schist. Some signs of ore were found, but nothing of value; so operations ceased in 1901. The venture was blighted by the fact that the Little Daisy claim was too small, and the most promising workings were close to the March claim; therefore Whicher made a trade with Hull whereby he acquired the four claims adjoining the Little Daisy, namely, the March, Conglomerate, Iron Carbonate, and Bitter Creek, in exchange for the various claims that the U.V.X. company owned around the United Verde property.

At the same time Whicher acquired the Little Daisy from Fisher for 5000 shares, so that now he had a compact piece of territory covering 75 acres, all below the line of the fault. Thereupon the Little Daisy shaft was sunk to 800 feet under Fisher's superintendence. He, unfortunately, did not live to see the fulfilment of his expectations, for he died in 1911.

Meanwhile, in 1910, the U.V.X. company had been reorganized under the laws of Delaware, with a capital of 400,000 shares of $10 each. The capital was diminished later to $750,000. From 1907 to 1911 C. C. Burger was consulting engineer, and expressed confidence in the venture. In 1911 R. M. Atwater examined the property for Whicher, and reported favorably; he concluded by saying: "I believe the chances of finding valuable orebodies are excellent". At this time (in April, 1911) Burger announced the finding of ore that assayed 2·6 to 3·1 per cent of copper, with $2 per ton in the precious metals, in a winze then 65 feet below the 800-foot level. The copper was in sulphide condition, but it showed signs of leaching.

A more important event was the finding of some 40 per cent chalcocite in a crosscut on the 700-foot level. This patch of sulphide proved to be 5 feet wide and 15 feet long; it averaged 18·7 per cent of copper, as reported by Burger. The discovery caused the shares to jump to $4; but it was a mere flash in the pan. Several other experts came to Jerome, and they reported adversely. Some of them accounted for the copper in the schist on the 800-foot level of the Little Daisy mine by supposing it to have been precipitated from solutions that had come from the United Verde orebody. The patch of chalcocite failed to impress them. Up to this time, $500,000 had been spent in exploratory work, and the enterprise languished. It was about to be invigorated by new blood.

In 1908 Major A. J. Pickrell purchased some stock from Fisher, and for a time served as a director of the company. Through him the U.V.X. obtained the financial assistance needed to bring the venture to fruition. In December, 1911, a

few days before Fisher died, the Major wrote to James S. Douglas, who was then at Douglas,* Arizona, urging him to come to Jerome and look into the U.V.X. business. Douglas, the son of Dr. James Douglas, who was long identified with the Phelps-Dodge corporation, had been to Jerome several times and knew something about the local geologic conditions. Upon his arrival, at the end of 1911, he was met by Major Pickrell and with him examined the U.V.X. workings down to the 800-ft. level, but no deeper, on account of water. What he saw impressed him so favorably that he commenced negotiations for an option. This option was submitted to Phelps, Dodge & Company, but it was rejected by them on account of a fancied defect in the title, whereupon Pickrell again urged Douglas to interest himself personally in the enterprise. His persuasion prevailed. Thereupon Douglas wrote concerning the project to his friend George E. Tener, then at Pittsburgh, and asked him to join hands in the proposed adventure.

In April, 1912, they engaged Ira B. Joralemon, then mining geologist for the Calumet & Arizona Mining Company, to examine the U.V.X. In his report, Joralemon stated that he would expect to find good sulphide ore at a moderate depth below the 800-foot level; he suggested that "the leached and crushed area in the Little Daisy might be part of a shear-zone, like that in which the great orebodies of Jerome occur. While the result of the work is a gamble, there is a chance of finding a mine worthy of being compared with the United Verde". He concluded his report in these words: "I think the chance is worth taking". This strengthened the purpose of the two gentlemen that had the matter in hand, Douglas and Tener, so they decided to ask a few friends to participate in the adventure, and, on August 14, 1912, they issued a circular letter in which a number of mining engineers and other friends were invited to join them in providing $225,-000 for the further exploration of the U.V.X. property. The

* Named after his father, Dr. James Douglas.

text of this letter deserves to be placed on record. The reader can decide for himself whether the invitation was such as would have induced him to participate in the gamble, for that it was frankly.

"George E. Tener and J. S. Douglas have secured an option on 450,000 shares of stock of the United Verde Extension Mining Company.

"The United Verde Extension Mining Company is capitalized at $750,000,* with 1,500,000 shares of a par value of 50 cents each.

"The original stockholders own, in round numbers, 400,000 shares, and George E. Tener and J. S. Douglas have an option on 400,000 shares and have paid $25,000 into the treasury of the company for 50,000 shares.

"500,000 shares will be left in the treasury.

"The option on the 400,000 shares runs to June 15, 1915, and the shares are to be purchased as the Treasurer may require funds for development work, at the discretion of the Board of Directors, who will be controlled by Mr. Tener and Mr. Douglas.

"As a commission for services, the United Verde Extension Mining Company are to pay Mr. Tener and Mr. Douglas 150,000 shares proportionately as the money is placed in the treasury. A proportion of the stock received by Mr. Tener and Mr. Douglas as commission from the United Verde Extension Mining Company is being used by them for organization purposes, but to comply with the law of the State of Delaware it must be issued to them for services rendered.

"They propose to extend to you the privilege of subscribing for . . . . shares at $0·50 per share, equals $ . . . . , this subscription being subject to the call of the Treasurer, Mr.

* This represented an increase to 1,500,000 shares of 50 cents each, as compared with the former capitalization of 500,000 shares of $10 each, as covered by the contract between Douglas and Whicher, the president of the company.

C. P. Sands, at 280 Broadway, New York, who will most likely call for 20 per cent of this amount on close of this subscription list, and the balance as needed, which will probably be at the rate of 20 per cent every three or four months. The Treasurer will forward stock to you as amounts are received in response to each call.

"It is proposed to expend $25,000 in development work on the present 800-foot level of the United Verde Extension

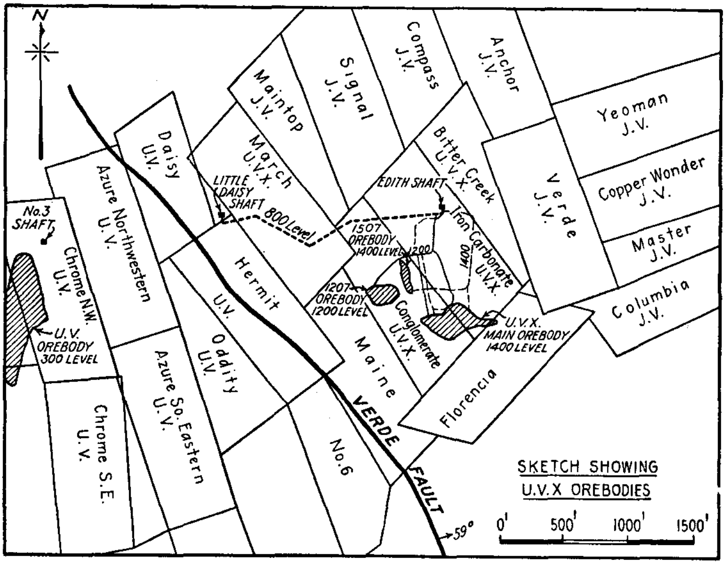


FIG. 27.

Mining Company's property at Jerome, and if the results are satisfactory to expend $200,000 at the rate of about $10,000 a month, crosscutting and drifting at that level.

"Mr. Tener and Mr. Douglas are not asking their friends for subscriptions, but believe that their plan for the development of the United Verde Extension Mining Company's property will result in the discovery of valuable orebodies, and in sending you this letter, it has occurred to them that

you might consider it a favor to be permitted to join in a speculation which they recommend as such."

This letter stated the facts plainly: it did not beg for financial assistance; the recipient had to form his own conclusions as to the merits of the venture. Those to whom it was sent were mostly professional men not only familiar with copper-mining operations in Arizona but also with the reputation for integrity that both of the promoters had won in the Southwest. Mr. Tener, then living at Pittsburgh, was known as an honorable and experienced mine operator; he was an organizer and one of the directors of the Calumet & Arizona Mining Company; yet it is no reflection upon him to say that it was mainly on Mr. Douglas's reputation for good sense and practical experience, together with implicit confidence in his good faith, that the money was subscribed promptly. It was raised in five successive calls of $40,000 each, so that, with the $25,000 that the two promoters had themselves furnished at the outset, there was $225,000 available for exploratory work.

The original prospecting shaft, on the Little Daisy fraction, had been sunk through the fault to a depth of 800 feet, as has been stated. The first exploratory work done by the new owners was to extend a drift eastward from a crosscut on the 800-foot level to the saddle on which the Edith and Audrey* shaft-houses are now standing. In this long drift a mass of quartz, of a promising character, was encountered. This led to the sinking of the Edith shaft, which was named after Mr. Tener's daughter. This shaft is 1900 feet east of the Little Daisy and was made partly by sinking and partly by rising for 300 feet, from the 800-foot drift. The Edith shaft went through 180 feet of lava, 400 feet of limestone, 90 feet of sandstone, and reached the schist at 670 feet, which depth geologically was equivalent to the 800-foot level of the Little Daisy workings. When the Edith shaft had been sunk below this level to 1200 feet, a drift was extended westward.

* Named after the daughter of Captain George Kingdon.

The drift found some ore in the corner of the Maintop claim, belonging to the Jerome Verde company;* at the same time another drift was started due south, and at a distance of 400 feet from the Edith shaft it was turned due west; at 250 feet beyond the turn this drift cut a lump of melachonite (the black oxide of copper) about as large as a bushel basket, say, a hundred pounds in weight. This happened in August of 1914. It was a mere flash in the pan; nothing more was found. At this juncture the two promoters engaged a mining geologist to show them where they had erred in their search for ore. After a careful examination, the scientific gentleman, whose name need not be recorded, condemned the venture and strongly advised the management to cease operations. However, even this wet blanket did not extinguish the flicker of hope that survived in the robust mind of Douglas, who decided to persevere.

In the September following Ygnacio S. Bonillas and Philip D. Wilson, the geologists, respectively, of the Copper Queen Consolidated and the Calumet & Arizona companies, examined and reported on the operations. They expressed the opinion that the evidence of rapid and incomplete oxidation of copper minerals in the workings on the 800-foot level, and also on the 1200-foot level, as exemplified by iron-stained siliceous material, quartz stringers, and flakes of native copper, all pointed to the existence of primary sulphide ore in the zone of fracture underneath, and that therefore there was a reasonable expectation of finding rich ore below, that is, at no great depth below the 1200-foot level. By September the $225,000 of working capital had been spent, and it became necessary to ask the shareholders to subscribe for their proportion of additional treasury stock at $1 per share. This they did forthwith. The issue, however, it must be noted, had been underwritten by Messrs. Douglas and Tener, so that the result

* In consequence, an option was taken on the Jerome Verde property, on a fifty-fifty basis, but this option was soon relinquished. About $400,000 of ore was taken out of the Maintop claim.

of it was never in doubt. Thus $50,000 more became available for further exploration. A little more work was done: the drift that was being driven toward the centre of the U.V.X. property on the 1200-foot level was extended a few feet farther, to a point about 150 feet beyond the place where the bunch of melachonite had been found in August. On December 20, 1914, this crosscut broke into 5 feet of 45 per cent ore!

It was the real stuff, at last! There was no more question about going forward with the development of the mine. The discovery proved to be part of a mass of ore 120 feet long that reached a few feet above the 1100-foot level. The first shipment, 76 tons, was sent to the United Verde smelter in February, 1915, and brought $75,000. From this orebody, about $600,000 worth of copper was obtained during 1915. The prospect had become a mine, but its wealth had only been touched. A drift was started on the 1400-foot level to cut the continuation of the ore that had been discovered on the 1200, but it went beyond the point where the ore ought to have been and found nothing. No crosscutting was done until January, 1916, because a heavy flow of water had been tapped south of the ore on the 1200-foot level. It became necessary to place electric pumps at the 1400-foot station. The exploratory drift on this lowest level had been stopped in a kaolinized rock that encouraged expectations of another orebody. It looked 'keenly', as a Cornishman says. This place was 850 feet south of the Edith shaft. As soon therefore as the pumps were in place and the level was drained—in February—a crosscut was driven both east and west on the 1400-foot level for the purpose of intercepting the north end of the high-grade ore found on the 1200-foot level; but both of these crosscuts drew a blank, because, as was ascertained later, the orebody had taken a dip westward below the 1200-foot level, so that the crosscuts were too far east.

The results were extremely disappointing, but there remained further scope for discovery. The next crosscut was started 100 feet farther south, and found nothing, but the third crosscut

at a distance of 40 feet from the drift cut into 16 per cent ore, and continued in ore for more than 200 feet. This was an entirely new orebody. The main level was extended into it and crosscuts were driven at intervals of 50 feet, proving that the orebody reached to within 30 feet of the Florencia side-line, the southern boundary of the U.V.X. property. On the 1400-foot level this orebody had a length of 440 feet and a maximum width of 260 feet; it covered 62,400 square feet. One ton of such ore occupies 7¼ cubic feet. The upward termination of the orebody was found to be at 1240 feet, and the downward limit at 1629 feet. The U.V.X. had become one of the great copper mines of the world.

During 1916, the year following these discoveries, the mine yielded 36,402,972 pounds of copper from 77,461 tons of ore, this being an average of 23·5 per cent of copper, besides 2570 ounces of gold and 128,468 ounces of silver, the total output being worth $9,949,918, of which $7,000,000 was profit! In the spring of 1917 the mine was estimated to have 2,000,000 tons of 15 per cent ore, representing 600,000,000 pounds of copper, to be produced at a profit of 10 cents per pound. The prize was worth $60,000,000!

In April, 1917, the mine produced 4390 tons of 38 per cent ore and 7029 tons of 29 per cent ore, together containing therefore 6,991,480 pounds of copper, worth $2,167,358—in one month, please note! When I first saw a carload of this chalcocite ore, just off the cage at surface, it looked to me like cannel coal; it blackened the fingers. That carload assayed 40 per cent. How it would have gladdened poor Fisher to see it. He deserved to share in the reward.

The 50-cent shares of the U.V.X. jumped to $45 as soon as the happy facts became known. Before the consummation, however, some of the shareholders, afflicted with a not unreasonable timidity, or 'cold feet', as you will, had sold out as soon as they could get back the money they had risked. Most of the participants, including, of course, the principals, held on, and in 1917, when I visited the mine, they had already drawn

$3·85 in dividends upon each 50-cent share. Those, not many, that were too "sane" to go into the "gamble" when they were invited to do so, were very sorry indeed, and there is reason to believe that thenceforth they smiled engagingly at almost any 'wildcat' that grinned at them from out the Arizonan cactus.

However, there were few heart-burnings and many rejoicings at the outcome of the undertaking. It requires courage, the grit of a real miner, to go through with an adventure such as the U.V.X. It needs luck also, for promising indications are often deceptive. How much of Douglas's success was due to such luck and how much to sagacity, it is impossible to say; he himself makes no claim to being the seventh son of a seventh son. He was aware of the fact that the rich ore-channel, as mined in the United Verde, was faulted; he could measure the extent of the fault; he could see the dip and direction of it; the work done by his predecessors had disclosed signs of mineralization, especially of chalcocitization; and he had reason to expect that any orebody he might find would be of high grade. The risk was great, but the possible winning was in proportion. His reasonable expectations, founded on general experience and local knowledge, were justified in the event, and he is entitled to the credit of a gloriously successful exploration. He insists, however, in characteristic fashion, that for his success he is indebted in large measure to the two successive superintendents of the mine, David Morgan and George Kingdon, who proved themselves exceptionally competent, both underground and on surface. Having some knowledge of the excellent manner in which the work was done, I take pleasure in placing their names in this honorable record.

Up to the end of 1930 the U.V.X. has produced 2,713,346 tons of ore, yielding 645,358,694 pounds of copper, 102,785 ounces of gold, and 5,025,003 ounces of silver. The ore has averaged 0·036 ounce of gold, 1·923 ounces of silver, and 11·85 per cent of copper. The recovery of copper has been 97·89 per cent. The mine plant has cost $2,086,860; the smelter, which was built in a hurry during the period of the World War,

represents an expenditure of $5,122,445. Thus the total outlay in plant has been $7,209,305. The total of dividends is $39,742,500, and the company retains $7,181,937 in cash assets, so that the total distributable profit is $46,924,437. There remains only about $4,000,000 to be won from the ore in reserve, for, despite intensive prospecting, no other large orebodies have been found and the life of the mine is unlikely to last for more than about three years more. The total winning will be about $50,000,000. To get at this Douglas and his friends had to spend $355,000, and even if we add the money spent unsuccessfully by their predecessors—say $650,000 more—the total amount of working capital consumed was only $1,000,000. The game was well worth the candle.

One word more; many of the richest mines in the world have been the cause of great financial loss to the public because they were over-valued on the stock exchange and their shares were bought at inflated prices. The *bonanzas* have been as much a source of regret as the *borrascas;* the genuine enterprises, by being grossly exaggerated, have done as much harm to the pockets of innocent folk as the calculated frauds. The U.V.X. has been free from anything of the kind; not much stock was sold at the high quotations, because the principal holders retained their stock even when, in 1916, it went up to $52 per share. Mr. Douglas, I may add, sold none of his stock until 1928, when he sold some, most of which he bought back later. He holds 56,000 shares now. The whole business has been clean from start to finish; it has justified the claim of Agricola that "mining is a calling of peculiar dignity".

CHAPTER XVII

THE GREAT DIAMOND HOAX

This story of the salting of a supposed diamond mine is a part of our Western history and deserves to be recorded in this book. It was more than a local affair, because it was concerned with persons in London and New York, as well as San Francisco.

Part of the story has been told by Asbury Harpending in a little book published 12 years ago. Harpending (who died at New York in 1923) was in London in March, 1872, when he received a cable dispatch from William C. Ralston, the president of the Bank of California, stating that "a vast diamond field" had been discovered "in a remote section of the United States". Before starting for San Francisco, Harpending had an interview with Baron Rothschild, who showed a lively interest in the story, which was as follows: two weather-beaten prospectors went to the Bank of California and deposited some uncut diamonds and rubies for safe keeping; these precious stones were estimated to be worth $125,000. The men said that they had found the gems in "a desert portion of the West". They departed quietly, but the story was told in business circles; whereupon George D. Roberts, a mining engineer of wide experience and an associate of Ralston, sought an interview with the prospectors. One of them proved to be a man that had been in the employ of Roberts. Both prospectors, named Slack and Arnold, appeared "coy and cautious"; they were "simple-minded fellows", and were "afraid to trust anyone with the momentous secret". They refused to divulge the place of discovery and declined "to part with their rights", but later "they became more amenable to reason" and expressed willingness to sell a half interest to

"gentlemen in whom they had such implicit confidence". They agreed, says Harpending, "to conduct two men, to be selected by Ralston and Roberts, to the diamond fields, and allow them to satisfy themselves as to the general nature of the find, but with this proviso: that these representatives, after reaching a wild uninhabitable country, must submit to being blindfolded, both going and coming back". The examination was made by David D. Colton and another, under these conditions. "More diamonds were unearthed and the party returned with rose-colored reports of the genuineness of the properties and their fabulous richness."

The place of the diamond deposits appears to have been kept secret at first, and even after this alleged examination by Colton and another, it was not stated publicly in what region the discovery was situated. At one time Arizona was credited with it, and most of the histories of the State contain references to the fiasco. Bancroft says that Arnold placed the site south of the Moqui towns, near the Colorado Chiquito.* McClintock says that the diamond mine was "somewhere north of Fort Defiance, in northeastern Arizona", and he suggests that these locations were made "merely for the purpose of diverting attention" because "in reality the field whence the diamonds came was south of the Moqui villages".† He was in error. In 1873 the Governor of Arizona, in his annual message to the legislature, expressed satisfaction that the press and people of the State, "much as they desired immigration", had not encouraged the diamond excitement.

It was at this stage of the proceedings that Harpending arrived in San Francisco from London. He found his friends greatly excited. The two prospectors, says Harpending, made "an offer to go to the diamond fields and bring a couple of million dollars worth of stones and place them in our possession as a guaranty of good faith". They departed. A week later they telegraphed from Reno asking that somebody meet them

* H. H. Bancroft, 'History of Arizona and New Mexico', p. 591; 1889.
† James H. McClintock, 'Arizona', Vol. II, p. 397; 1916.

at Lathrop. Harpending went; he says: "I had a long wait at Lathrop, but at last the expected Overland [train] pulled in. I located the men without difficulty. Both were travel-stained and weather-beaten, and had the general appearance of having gone through much hardship and privation. Slack was sound asleep like a tired-out man. Arnold sat grimly erect like a vigilant old soldier with a rifle by his side; also a bulky-looking buckskin package". They told Harpending that they had lost one package of stones while fording a river—by the way, in a "desert" country—but that "as the other contained at least a million dollars worth of stones, it ought to be fairly satisfactory". On arrival at Oakland they handed the bag of diamonds to Harpending, who went immediately to his home, where his associates had assembled. "We did not waste time on ceremonies. A sheet was spread on my billiard table, I cut the elaborate fastenings of the sack, and, taking hold of the lower corners, dumped the contents. It seemed like a dazzling many-colored cataract of light!"

The diamonds were displayed later in open trays to the sight of the people of San Francisco. Local excitement was tremendous. Several persons went to the prospectors and bought an interest in the discovery, which, it was understood, was owned as to three-quarters by Ralston and his friends. A sample of the stones was sent to Tiffany, the jeweler, in New York, and a party of six, including Harpending and the two prospectors, proceeded thither. Tiffany reported that the sample was worth $150,000. "At that figure, we had diamonds enough already in stock to make up a total of $1,500,000 in hard cash." That seemed "regular velvet to begin with".

All that was needed now was to send a mining expert to confirm the value of the discovery. Henry Janin, a distinguished engineer, was engaged to make the examination; he, accompanied by three others, including Harpending, was conducted to the mine by Slack and Arnold. They proceeded to Rawlins, in Wyoming, and went from there by an indirect

route over rough country to "the spot". Arnold and Slack in their zigzag course had actually brought them within twenty or twenty-five miles of the railroad, but Arnold assured Harpending, with a smile, that the railroad was "at least a hundred miles away". The party proceeded to search for diamonds, by aid of pick and shovel. "Everyone wanted to find the first diamond. After a few minutes Rubery gave a yell. He held up something glittering in his hand. It was a diamond, fast enough. Any fool could see that much. Then we began to have all kinds of luck. For more than an hour, diamonds were being found in profusion, together with occasional rubies, emeralds, and sapphires."

Apparently even Janin overlooked the discrepant character of the evidence, for rubies, emeralds, and sapphires are not found in the same rocky matrix with diamonds. "Mr. Janin was exultant that his name should be associated with the most momentous discovery of the age." In two days he was satisfied of the "absolute genuineness of the diamond fields" and advised the immediate location of the adjacent ground so that "one great corporation" might have "absolute control of the gem market".

Janin's report is quoted in the 'Engineering and Mining Journal' of September 3, 1872. It appears in the 'Mining Summary' under the heading of 'Arizona'. That is where the diamond fields were supposed to be, but a reference is made to "the efforts to conceal their precise location". Most of the report is given verbatim, but not the first paragraph:

"He says while at the diamond fields, there was washed of rich gravel less than, but say, three thousand pounds, or one and a half tons. This amount of work was done by Messrs. Slack and Arnold principally, the only experienced washers, assisted at times by myself and other members of the party. The total amount of work done was under, but say, four days' work of two men, or eight days' work of one man. This amount of labor produced 256 carats of diamonds, first quality, worth $16 per carat, or $4096; 568 carats diamonds, second

quality, worth $3 per carat, $1704; 824 carats, $5800. Further, of rubies, four pounds, or 7200 carats, worth 50c. per carat, but estimated at 30c.—$2160. Total produce of one and a half tons of gravel, $7960, or $5306—say $5000—per ton. The estimate was made on a conservative, commercial and selling basis, and ignored the fact that while none of the diamonds were worthless, many were large enough to be worth much more per carat than $16 . . . The washing was done by hand in ordinary gold pans; with the assistance of even the simplest machinery (gold rockers), the results of the same quality of gravel would have been increased many-fold by the same number of days' work. One thousand tons of such gravel as this would produce $50 per share and would more than cover the purchase price and expenses of production."

Then follow other estimates based on the foregoing. The report continues:

"Our stay at the diamond fields was so short (we were in camp at the field only seven days), and there was so much to be done in the way of locating, surveying, and securing the property, water rights and timber lands, that it left much less time than I desired, in which to prospect and sample this tract of ground. To prospect the whole tract of nearly 3000 acres would occupy months. I had only time to gather samples from those portions of the 160-acre block of ground which are marked in the accompanying plat. The amount of prospecting done was insignificant, and does not enable me to form a judgment as to the extent or limits either of the very rich or only moderately rich ground."

This is followed by details concerning the water-rights and timber, after which he says:

"In conclusion, I would say that I consider this a wonderfully rich discovery, and one that will prove extremely profitable. That while I did not have time enough to make the investigations which would have answered very important questions, I do not doubt that further prospecting will result in finding diamonds over a greater area than is as yet proved to

be diamond-bearing; and finally, that I consider any investment at $40 per share, or at the rate of $4,000,000 for the whole property, a safe and attractive one."

This report is open to several obvious criticisms. If the time spent on the ground was insufficient for a satisfactory examination, Janin should not have written the final paragraph, in which he pronounced the "investment" safe for $4,000,000. As the sequel proved, his investigation was so perfunctory that no opportunity was given to detect an abject fraud. The deposit is described as "gravel", as if it were an alluvial deposit. The panning of samples was done "principally" by the two vendors, and probably the selection of the places to be tested was left largely to them. Janin should have taken an "experienced washer" with him if he was unprepared to do the panning himself. As it was, he played into the hands of the two rascals like any tenderfoot.

The party, accompanied by Janin, went from Wyoming to New York. "In a brief space . . . all the civilized world knew that vast diamond fields had been discovered on the North American continent, had been inspected by a mining engineer of great reputation and pronounced genuine." Rothschild cabled to Harpending, who replied that "half the truth had not been told; but the diamond fields were rich beyond calculation". Indeed, it is not surprising that after Tiffany's valuation and Janin's report "every suspicion gave way to an unbounded enthusiasm".

On June 30, 1872, a company with a capital of $10,000,000 was organized in California. "Twenty-five gentlemen, representing the cream of the financial interests of the city of San Francisco, men of national reputation for high-class business standing and personal integrity, were permitted to subscribe for stock to the amount of $80,000 each, and this initial capital of $2,000,000 was immediately paid to the Bank of California." The men that became the directors of the company "stood as the last word in the financial and commercial world of the Pacific Coast". One of them was the representative of the

house of Rothschild, which became the company's agent in Europe. "The interest of Slack and Arnold was wiped out finally by a cash payment of $300,000."

The directors dispatched a consignment of diamonds to Rothschild, and sent a party of miners and surveyors, headed by Roberts, to the diamond field. Meanwhile not a share of stock had been placed on the market, "although the excitement was intense". Roberts and his party confirmed all that had been said; he asserted that "if they had been deceived they were the worst deceived and cheated men who ever lived". They were. The package of diamonds brought back by the Janin party was valued at $20,000, but Tiffany estimated it to be worth only $8000. This discrepancy was disregarded.

By that time "everything was closed down for the winter". One wonders why the company dared to leave such a treasure unprotected. Fortunately, no share speculation had been started, but handsome offices were engaged, and in it was displayed a map of the 3000 acres claimed by the company, showing the relative positions of Diamond Flat, Ruby Gulch, and Sapphire Hollow, but omitting the site of Sucker Valley.

That significant spot was exposed suddenly on November 11, 1872, when the president of the company received a telegram from Clarence King, at that time at the head of the Fortieth Parallel Survey and later the first Director of the U. S. Geological Survey, stating that the diamond discovery was a hoax and that the ground had been salted. The telegram came from Wyoming. The directors were stunned. They held a meeting, says Harpending, and asked King to take a party to the alleged diamond deposit. Accordingly Janin and three others started immediately. King went with Janin and his party to the alleged diamond field, and showed them the evidence of fraud.

In the 'Engineering and Mining Journal' of December 10, 1872, the fiasco is exposed. Clarence King's report is given in full; also the second report by Janin. Apparently King came to San Francisco as soon as he had discovered the fraud; he addresses his report to the directors of the New York & San

Francisco Mining & Commercial Company in these words: "I have hastened to San Francisco to lay before you the startling fact that the new diamond fields upon which are based such large investment and such brilliant hope are utterly valueless, and yourselves and your engineer, Mr. Henry Janin, the victims of an unparalleled fraud". He proceeds to explain that he made the examination, "feeling that so marvelous a deposit as the diamond fields must not exist within the official limit of the geological exploration of the Fortieth Parallel, unknown". He was "enabled to find the spot without difficulty, reaching there on Nov. 28 . . . Our first day was devoted to the sandstone table rock, at the head of Ruby Gulch, where about all the stones collected by your parties have been gathered, and had our critical work ended with the close of this one day, we should have left the ground confident believers in the genuineness and value of the fields. My suspicions were, however, aroused early in the second day's work, and I at once determined to make an exhaustive series of prospects, of which the following are the results:

"First—A nearly uniform numerical ratio exists between the rubies and diamonds.

"Second—The gems, in nine cases out of ten, lie directly upon the hard surface of rock or an indurated crust of soil. In the exceptional cases, where I found them in crevices, there was always ample evidence that the sand or soil had been disturbed and broken up within a year.

"Fourth—Ruby Gulch, leading directly from Table Rock to Arnold Creek, and by necessity receiving the wash of the gem-bearing surface of sandstone, was found to be extremely rich in rubies at the head; but this richness, instead of continuing down the creek, as if genuine, it inevitably must be, proved to exist only in ground directly at the foot of Table Rock, where the soil was clearly disturbed, mixed and smoothed over . . .

"Sixth—Upon raised dome-like portions of Table Rock rubies and diamonds lay upon the summits and inclined sides

in position where the storms of one or two winters must inevitably have dislodged them . . .

"Seventh—An exhaustive examination of the rock-material itself, with a field microscope, revealed no grain, however minute, of either gem.

"Eighth—In the ravines and upon the mesa near by are numerous anthills of small pebbles, mixed by the ants, and which we found to bear rubies on their surface. A still closer examination showed artificial holes, broken horizontally with some stick or small implement, through the natural crust of the mound; holes easily distinguished from the natural avenues made by the insects themselves. When traced to their end, each artificial hole held one or two rubies. Moreover, about these 'salted' hills were the old storm-worn footprints of a man.

"Ninth—I discovered in the Table Rock three small emeralds. Summing up the minerals, this rock has produced four distinct types of diamonds, Oriental rubies, garnets, spinels, sapphires, emeralds, and amethysts—an association of minerals I believe of impossible occurrence in Nature.

"The results of these ten links of proof are: that the gems exist in positions where Nature alone would never have placed them; that they do not exist where, had the occurrence been genuine, the inevitable laws of Nature must have carried them. Finally, that some designing hand has 'salted' them with deliberate fraudulent intent. Furthermore, this is the work of no common swindler, but of one who has known enough to select a spot where every geological parallelism added a fresh probability of honesty. The section of the geological locality is so astonishingly considered, the 'salting' itself so cunning and artful, the filling of all the conditions so fatally well done, that I can feel no surprise that even so trustworthy and cautious an engineer as Mr. Janin should have brought home the belief he did, especially when, as his report states, he was not allowed to prospect exhaustively; nor do I wonder that your second party of ten men brought back a confirmation of Mr.

Janin's opinion, since they, too, were hurried from the ground without actually testing it . . ."

The report is signed "Clarence King, U. S. Geologist". I have not quoted all of it, because it is unnecessary to do so. King magnifies the cleverness of the deception partly to soften criticism of his friend Janin, and perhaps also unconsciously to emphasize his own skill in the detection. He did no more than any competent mining engineer should have done; the fraud was a piece of "coarse work", and should have been detected by both Janin and King after any real investigation. The reason why the "second party of ten men" confirmed Janin's first report was because they omitted, as he did, to make adequate tests, or to remain on the ground long enough to gather the necessary clues. It seems to me that the fraud *was* the work of a common swindler and that "geological parallelism" *was* distinctly lacking, for the presence of diamonds in company with three or four other different kinds of gem-stones presents a distinct geologic discrepancy. The salting itself was so little "cunning and artful" that the diamonds and rubies were placed loosely in natural crevices, the piercing of the anthills was performed so carelessly as to be visible, and the footmarks of the perpetrators were so little disguised as to remain in plain sight for months after the fake had been concocted.

King's report is followed by Janin's second report. It is dated November 25, 1872, and gives the result of his second visit to the ground, accompanied by King. Janin says, in part:

"We have examined all the points tested by Mr. King, and have made numerous additional tests, all of which go to prove that he was right in his conclusions, that the ground is absolutely worthless and not diamond-bearing, and that it has been made the field of an ingenious and infamous fraud. In company with General Colton I repeated the tests made by me on the occasion of my first visit, at points a third of a mile distant from the 'discovery' point, where I had previously

found and reported diamonds and rubies. Innumerable tests showed the ground to be absolutely barren, showing that the gems found were placed in the various samples of gravel taken, between the time they were collected and the time when they were washed. These tests were made in company with one of the original and supposed discoverers."

"These tests" refers to the panning done at the time of Janin's first, and perfunctory, examination. His statement indicates that not only was the ground salted, but that the samples likewise were doctored during the time they were being tested. He describes in detail the confirmation of King's conclusion and then proceeds:

"We gathered diamonds and rubies from the bare pieces of sandstone above, as has been done by every party visiting the ground. Here, too, the conditions of fraud are numerous and irresistible. Since I professionally examined and indorsed this supposed discovery, the responsibility of investments made subsequent to my report and the consequent losses of course rests upon me. In partial explanation of the apparent ease with which I was befooled, I must be allowed to go back to the time when I first heard of this affair, when my services were engaged. In the latter part of last May I was in New York and was called upon by two gentlemen of this city, both at present large shareholders in the enterprise and with their own means largely engaged in the same. They laid the story before me and silenced the incredulity which it naturally excited, by the statement that they themselves had investigated the matter closely; that they were assured by the original prospectors, and believed that two trips had already been made by them to these fields, at long intervals, and that each trip had resulted in the production of large values in precious stones, although their work was done hastily and with rude implements . . .

"While discounting in my own mind very largely the statements of the prospectors as quoted to me, they still left me firmly impressed with the belief that such large sums had been

obtained from this ground as to preclude any suspicion of 'salting'. Diamonds and rubies, both in the rough and polished state, were shown to me, and in good faith, as coming from these fields. The diamonds were, many of them, of considerable value, and were ranked as a high average quality by New York lapidaries. The diamonds picked up by the last expeditions are mostly small and worthless, and are the refuse of what was obtained by the earlier expeditions. On my way out I was told in great detail the story and adventures of the two so productive trips. I looked upon my investigation as undertaken not to determine the fact of the discovery, but to ascertain approximately the extent and value of the same . . . Had I been allowed more time, as I desired, in which to make my investigations, it is probable that I would have detected the fraud. At the same time, it is possible that the same 'salting' game might have been kept up, and my good opinion of the property have been not only confirmed but increased . . . A further explanation of the mistaken opinions of myself and others is found in the patient, ingenious, and audacious nature of the fraud."

So ends the report; it is ingenuous, and frank in its acceptance of blame. In the same issue of the 'Engineering and Mining Journal' there is an editorial article, entitled 'The Diamond Swindle'. It was written by Rossiter W. Raymond. Again Janin is fortunate in finding a friend ready to minimize his blunder. Raymond, King, and Janin were among the first men in the profession at that period—50 years ago—and they were close friends. Dr. Raymond endeavors to explain "the otherwise astonishing phenomenon of an engineer like Mr. Janin, consenting, after so much preparation, to leave his work half done, and to present a preliminary, where he intended to render a conclusive, report". His explanation is that Janin was "hurried away, after a single day's prospecting", and that "a great deal of clerical work devolved upon him, by reason of the illness of the only other person in the party who could discharge it; and when, after all preliminaries

[this refers to surveying, locating, and preparing records] were completed, the work of prospecting actually began, it was continued but a single day, before the sick man [a representative of the capitalists] peremptorily insisted on being taken away, declaring he should die if he remained longer in the wilderness". These facts, says the editor, "come to us on excellent authority".

Then follows a reference to King's report, with the remark: "It now seems beyond doubt that the locality (which is in Colorado) was skillfully 'salted' with small stones, while large ones were from time to time introduced into the samples taken for testing, during the process of washing. That Mr. Janin, like most of his profession in this country, had had no practical acquaintance with the geology, topography, and special conditions of diamond fields was no disgrace to him. That he did not suspect a fraud, even, was natural enough. He was sent to report on the probable value of a discovery which had furnished precious stones for more than a year; his employers did not request him to test its genuineness, but to determine its extent". This is kind, but not altogether convincing. He did not remain on the ground anything like long enough to "determine its extent"; and an engineer is expected, of course, to satisfy himself of the "genuineness" of a deposit before he begins to value it in terms of millions of dollars. Raymond seems to appreciate the weakness of his apology; for he adds: "But when all is said, the fact remains that an acute, experienced, and upright man allowed himself to be outrageously deceived, in a case involving his own hard-earned reputation, and an enormous pecuniary interest . . . Of course, this matter will be laid at the door of 'science'—but most unfairly. The combination of circumstances that deceived one of the shrewdest experts on the Pacific Coast might have misled any scientific man in the country, who did not absolutely disbelieve all men and all superficial phenomena".

To which I would remark that an engineer when about to examine a mine should write *caveat emptor* on the first page of

his notebook. Raymond senses this, for he continues: "But the scientific spirit is that of entire scepticism and fundamental investigation. Mr. King's work was scientific, yet he confesses that if his examination had ended with the first day, he would have been convinced as Mr. Janin was. It was his continued investigation that brought out the truth; and it was Janin's unfortunate failure, through causes apparently beyond his control, to make such an investigation, and his fatal error in consenting to give a 'preliminary opinion' that cost him so dear". That is true.

If King had gone all the way to the place of the supposed discovery and had spent only one day there, he would not have done his work as a geologist in a "scientific" manner. The methods of science are thorough and sincere. Raymond proceeds to state that "this is a startling lesson for mining engineers". He refers to previous editorial warnings against the trickeries of the promoter's trade, and ends with the regretful statement: "Henry Janin's mistake may well teach us all humility and caution". With this I concur heartily.

In after years even Raymond himself was grossly deceived in his estimate of the ore in the Chrysolite mine at Leadville, and others of us at some time or another have been barely fortunate enough to detect fraud in time to prevent a public fiasco. Henry Janin survived the blow to his reputation and regained his standing in the profession long before he died, on January 6, 1911, nearly forty years after the events that I have described. The moral of his story is that an engineer should avoid expressing a premature opinion; he should write no report until he has ascertained the facts; and, more particularly, he should be intensely sceptical of any alleged new diamond field in the United States, or elsewhere.

The party that accompanied King and Janin in this final examination returned to San Francisco, and on November 25 the facts were given to the press, "that the diamond fields were a fraud, and that everyone had been taken in". An investigating committee was appointed. A disgusted confederate

gave useful evidence. It appeared that Slack and Arnold had bought a parcel of the small diamonds used for drilling; a dealer in London identified them as having been purchased from him a year before. This information should have been available sooner, for it was based on the examination of the consignment sent to Rothschild for sale some time in July. The subscriptions of the 25 shareholders, aggregating $2,000,000, were returned to them. The only loss incurred was the money paid to the perpetrators of the fraud and the expenses of the various expeditions, all of which were met by Ralston and his associates. The general public did not lose a cent.

The diamonds used in the salting came from South Africa and were bought by Arnold in London. The stones were of the inferior kind used for glass-cutting, diamond-drilling, and other utilitarian purposes. It must be remembered that in 1872 not much was known about diamonds or their mode of occurrence. The diamantiferous deposits of South Africa were discovered in 1869 and the mining of them may be said to have started in 1871. Before that the chief source of brilliants was Brazil, where the diamonds are found in sand and gravel derived from a conglomerate of micaceous sandstone. Perhaps that was why Arnold selected a sandstone for the scene of his fraud. The South African diamonds are found in a volcanic plug, which consists of a breccia of several rocks, chiefly peridotite. Sapphires are found in Montana and Canada in dike-rocks, such as lamprophyre, andesite, and syenite. Rubies and emeralds are found in pegmatite.

Several interesting discrepancies are to be noted in the details of the story. Harpending says that Slack and Arnold received "approximately $600,000", and that the salting was done with stones that cost them "about $35,500". He says that they received finally a cash payment of $300,000, but he does not say when or how they were paid the second $300,000. On the other hand, the first parcel of diamonds, which was deposited by Slack and Arnold at the Bank of California, was said to have been worth $125,000. Next the consignment sent

to Tiffany was estimated by him to be worth $150,000, whereupon the diamonds "already in stock" were given a value of "$1,500,000 in hard cash", as Harpending asserts. Obviously, the value of the stones was absurdly over-rated from start to finish, and Tiffany's appraisal was largely to blame. He apparently did not know how to appraise uncut stones, his experience having been only with cut gems. His name even then carried much weight in the gem market.

It is one of the humors of the swindle that the discards of the diamond trade, bought for $35,000 only, should have sufficed to create an estimate of more than $1,500,000, for it must be remembered that all the stones were not recovered. Some of them must still remain where they were placed, in Colorado, a few miles south of the Wyoming boundary. In Harpending's tale he describes the "dazzling many-colored cataract of light" that he emptied on the table from the bag that the prospectors brought to San Francisco. Uncut stones are not "dazzling", or even brilliant; they are dull, like pieces of ground glass. Evidently imagination entered into play. That some of the diamonds were cut stones is likely; indeed, it was part of the crudity of the swindle that one or more cut stones were used in the salting. Harpending says that King obtained his clue from the finding of a cut stone by a German member of his staff, and there is evidence to corroborate this statement, the man that detected the evidence of the lapidary's art being a certain Schmidt, who had had some experience with gems.

Suspicion of the complicity of some of the promoters was aroused at the time, but there is every reason to accept Harpending's assertion that they were dupes, not conspirators. Slack, it seems, received only $30,000; he disappeared, and no trace of him was ever found. Arnold went to Kentucky, where he settled down to enjoy a quiet life. When the fraud was detected a lawsuit was started against him in the local court, to which he replied by denying the salting and asserting that if there had been any it must have been done by the "California scamps". He brought forth Janin's report and

Tiffany's appraisement in proof of his own honesty. His neighbors thought him a fine fellow, and supported him cordially. In the end, after sundry negotiations, he compromised and surrendered $150,000, in consideration of immunity from further litigation. But he did not live long to enjoy his ill-gotten gain; he was shot in an altercation on the street and died soon afterward, at the end of 1873.

CHAPTER XVIII

THE FLOTATION PROCESS IN THE UNITED STATES

The introduction and development of the flotation process have proved to be of such momentous importance to the mining industry of the United States that they deserve to be considered historically.*

The origin of the use of oily matter in separating minerals in ores is obscure, because its beginnings were unregarded. The story told by Herodotus concerning the recovery of gold from the mud of a lake by means of feathers daubed with pitch in the hands of apocryphal virgins is as pertinent to our inquiry as the yarn, two thousand years later, of a young school-teacher in Colorado that was washing oil-stained ore-sacks in her brother's assay-office when she noted the floating of pyrite on the water contaminated by the oil. In any event, the method patented by Carrie Everson in 1885 was a complete failure, except as factitious evidence for trying to disprove the originality of subsequent inventions.

An early and inadvertent use of the affinity of oil for metallic surfaces is suggested by the story of Jason and the Argonauts, who extracted gold from the gravel of the river Colchis by means of sheepskins. The woolly hide served, like the blankets used in our early stamp-mills, to arrest the gold, which was further detained by the oil on the fleece. Strabo, referring to a later period, says that in the country of the Soanes, who inhabit the valley of the Colchis, "the winter torrents are said to bring down even gold, which the barbarians collect in troughs pierced with holes, and lined with fleeces; and hence the fable of the Golden Fleece".† William Pryce

* T. A. Rickard, 'Flotation', p. 9; 1917.

† Strabo's Geography, XI, 2, 19.

describes the use of a similar method in Brazil. "The inhabitants of Brazil", he says, "will sometimes find a kind of gold-dust, so very weak and minute, that they cannot save it well in bowls [*bateas*]. This has obliged them to have recourse to another method of making the most of this very small gold-dust, by laying an oxhide on the ground, with the grain of the hair against the water, which passes gently over it. On this they stir and mix the sand and gold-dust; by which means the small particles sink and are intercepted in the hair of the hide, while the sand washes off."* The saving of the gold was aided by the oil on the hide.

Hezekiah Bradford, an American, also in 1885, obtained a patent that was based upon the recognition of the surface-tension of water when in contact with air. Surface-tension is the contractile force at the surface of a liquid whereby resistance is offered to rupture. These early experimenters had an inkling of the physical phenomena underlying the flotation process, but they were pioneers that blazed no trail. More significant was H. L. Sulman's British patent of 1893 in which he described a means for saving float gold by adding something to the mill-water that would diminish its surface-tension. Mr. Sulman was destined to be a true pioneer, because, not only had he the advantage of a scientific training, but his professional participation in the oil and soap industries gave him knowledge of a kind that was applicable to the metallurgic process with which his name is now imperishably associated.

In 1894 George Robson and Samuel Crowder patented a process, in England, for the separation of metallic matter from gangue by the use of a large proportion of oil. It was a method of buoying the sulphide particles in oil. A trial at the Glasdir gold mine, in Wales, proved a technical success, but an economic failure. Two years later, in 1896, William Elmore bought the Glasdir mine, and sent his two sons, Francis Edward and Alexander Stanley, to investigate the method of concentration as applied to the gold-bearing copper-pyrite in

* William Pryce, 'Mineralogia Cornubiensis', p. 246; 1778.

the ore of this Welsh mine. There the Elmores saw Robson's experimental plant, and they hardly needed Crowder's urge to proceed with the effort to use oil as a means of concentration.* In 1898 Francis Elmore obtained his first patent, which led to the formation of a strong syndicate and to the building of a mill at the Glasdir mine.

In his patent Francis Elmore described the process as "mixing the pulverized ore first with water in considerable quantity, then adding to the mixture an oil of the kind described, which adheres to the metallic constituents but not to the wet rocky constituents". The metallic constituents are not wetted, because they are oiled. Elmore used a thick oil and introduced the idea of a freely flowing pulp as against the mixing of oil with crushed ore in the presence of only a small proportion of water, as Robson and Crowder had done. By using more water, he also entrained more air, so essential to success, although he did not then recognize the fact. Charles M. Rolker read a paper on the Glasdir mill before the Institution of Mining and Metallurgy in London on April 25, 1900.† The paper and the discussion show clearly that nobody at that time recognized the part played by air in this oil-concentration process. The manager of the mill had testified that the floatative efficiency of the oil was 150 per cent greater than had been expected; that is, the actual load of concentrate on the oil was that much greater than anticipated. Francis Elmore remarked upon the difference between theory and practice. Rolker imputed it to the viscosity of the oil. Neither Sulman nor H. F. K. Picard, the later protagonists of flotation, both of whom took part in this discussion, made the slightest reference to the agency of air, which was entrained with the ore and the water while they were being mixed in the revolving drum. Three years later Stanley Elmore actually took out a patent wherein air was specifically excluded from the operation. It is

* *Mining and Scientific Press*, February 24, 1917 and June 16, 1917.

† Charles M. Rolker, *Trans.* Inst. Min. and Met., London, Vol. VIII, p. 379; 1900.

certain that in 1900 the agency of air—the bubble-making phase—was not understood by any of the exponents of oil-concentration.

In 1901 the Elmore syndicate established a demonstration plant in London, and in due course a number of mills for applying the bulk-oil process were built at mines scattered all over the world, notably in Wales, Cornwall, South Africa, and British Columbia. Meanwhile experiments were being made at Broken Hill, in Australia. Charles V. Potter and Guillaume D. Delprat patented processes in which, for the first time, we have mention of bubbles that served to raise the ore particles to the surface of the pulp in a mill. They expected to make their bubbles by generating gas by means of some acid that they added to the pulp. They did not use oil, but as they were engaged in treating old dumps, we may infer the presence of oily compounds* suitable for lowering the surface-tension of water and thereby facilitating the formation of bubbles. Large quantities of dump material were milled successfully by flotation methods at Broken Hill between 1903 and 1905.

The scene shifts from Australia to Italy. In 1901 Alcide Froment, an engineer at the Traversella mine, invented a modification of the oil-concentration process, this modification, patented in June 1902, being the introduction of a gas into the freely flowing oiled pulp used by Elmore. He argued, in his patent, that "if a gas of any kind is liberated in the mass the bubbles of the gas become coated with an envelope of sulphide and thus rise readily to the surface of the liquid where they form a kind of metallic magma". The phrase "gas of any kind" is important, for, although he generated his bubbles of gas by the reaction between sulphuric acid and the carbonates of the gangue or between the acid and the limestone that he added to the pulp, he had hit upon one of the fundamental principles of the flotation process as we know it today. If he had specified air as the particular gas to be

* T. J. Hoover, 'Concentrating Ores by Flotation', p. 101; 1912.

used he would have been acknowledged as a pioneer of flotation. Air was present, of course, and played a decisive part in the operation, for he specified the employment of a centrifugal mixing device "in which two stirrers work in opposite directions, making 300 revolutions per minute". His British patents were acquired by the Minerals Separation Company in 1904, and Froment died soon afterward.

Now we come to the Minerals Separation Company, which has played the chief part in the later development of the process. In 1901 John Ballot organized a syndicate to take an option on the Australian rights to the Elmore bulk-oil process. He engaged the firm of Sulman & Picard as advisory metallurgists. Acting upon their advice, the syndicate did not exercise the option. In December 1902 Ballot purchased the patents of Arthur Cattermole and assigned them to his syndicate, which was named the Cattermole Ore Concentration Syndicate. On December 31, 1903, this syndicate was reorganized as Minerals Separation Limited.

Cattermole, in his patent of September 28, 1903, refers to the selectiveness of oil, when emulsified, for sulphide particles, such selective action being intensified by acidulation of the water.* He then says that if the mixture be agitated thoroughly there is a tendency for the metalliferous particles, now well coated with oil, to adhere together, forming granules that sink and are readily separated from the lighter gangue by a rising current of water. He specifies the proportion of oil as between 4 and 6 per cent of the metalliferous mineral matter in the ore. Evidently he missed the fact that his thorough agitation of the oiled pulp made multitudinous bubbles, that is, froth. It is stated that in the course of experimentation with the Cattermole process in the laboratory of the firm of Sulman & Picard, in London, a series of tests was made with variations in temperature, acidulation, oiling, and mixing. When the proportion of oil was reduced, the granules began to rise, the best results being obtained when there was less than 0·62 per cent of the

* T. A. Rickard, 'The Flotation Process', p. 40; 1916.

oil (oleic acid) on the ore. The experiments were conducted by Arthur H. Higgins, in the laboratory of Sulman and Picard; and the ensuing British patent, No. 7803, was obtained in the names of Sulman, Picard, and Ballot on April 12, 1905. It was followed by the American patent, No. 835,120, taken in the name of the Minerals Separation Company on November 6, 1905. This was the basic American patent; it proved sufficient to cover the rights to froth-flotation.

Meanwhile, as early as 1901, in the use of the Cattermole process in the Central mill at Broken Hill, it had been remarked that a scum laden with sulphide mineral was formed whenever the rotation of trommels, or the motion of jig-plungers, or the splash of elevators produced a violent agitation of the mill-water containing slime. The use of oil served to make this foam more persistent. In 1902 it was noticed that the scum of slime from re-crushed tailing was saved by floating it over a spitz-box. W. Shellshear and F. A. Beauchamp suggested the application of this idea to correct the failure of Cattermole's granulating process, which suffered from the fact that floccules of mineral broke away from the granules on the concentrating tables. Their suggestion was adopted in 1903. It was discovered that the floatative effect was produced when using 9 pounds of oil and 22 pounds of acid per ton of ore. The proportion of oil was diminished gradually to two pounds per ton of ore. This was the beginning of froth-flotation. In 1904, after a 50-ton Cattermole plant had been built in the Central mill, a number of experiments were made by George A. Chapman, one of the able men on the staff of Minerals Separation. His tests showed that when using 15 pounds of oil per ton of ore he obtained excellent results, "with all float concentrate, no granular material being formed". In other words, the Cattermole process was discarded. The importance of the floating does not seem to have been appreciated until early in 1905, when "a remarkable development in the operation", says James Hebbard, the manager of the Central mine,

"was discovered (strangely enough, at the same time here [Broken Hill] and in the patent company's [Minerals Separation] laboratory in London) which had for its main principle the reversal of all previous operations, and consisted in the complete flotation of each particle of mineral independently in place of granulating the mineral particles and causing them to sink, thus not only revolutionizing the process, but greatly simplifying and cheapening it. The developments noted were mainly along the line of decreased consumption of oleic acid, for example, from 3 per cent oleic on ore, resulting in very little float down to 1 per cent, giving practically a complete float".* According to this, the discovery of the agitation-froth process was made independently and contemporaneously in London and at Broken Hill. It only remains to add that Chapman had experimented with the Froment process in the London laboratory in 1903. Like many other interesting industrial discoveries, that of flotation has been obscured by the exigencies of litigation, and it is difficult to get at the facts now. It is fair to add, however, that the observations made in the mills at Broken Hill prior to 1905 concerning the floatative effect of scum or foam were without inventive result; those that made them did not appreciate their real significance at the time, although they spoke of them appreciatively after patent 835,120 had been issued. They did not publish anything at the time and they did not seek to patent their ideas. The productive observations were those based upon the experiments of Sulman and Picard in London, because these led directly to the discovery by Higgins, and the ensuing patent. Here note may be made that the Broken Hill milling by flotation was done in heated solutions, whereas the American adaptation of the process was distinguished by the use of unheated circuits.

So far oil-flotation had received scant attention in the United States. In 1899 Charles Butters tried to introduce

* James Hebbard, Australasian Inst. Min. Eng., *Proc.*, November 10, 1913.

the use of the Elmore process, and established an ore-testing plant for this purpose at Salt Lake City. He used a centrifugal machine to separate the excess of oil from the concentrate. The results showed no betterment on water concentration, and the high proportion of oil—20 pounds per ton of ore—"made a fearful mess", as Butters himself remarked.* The Elmore process of bulk-oil flotation was tried, unsuccessfully, at the Boston Consolidated and Mammoth mines in Utah during 1900 and 1901. In 1906 a surface-tension method of remarkable ingenuity, invented by A. C. Macquisten, was used in the Adelaide mill, at Golconda, in Nevada; and in 1911 a similar plant was built at the Morning mine, in Idaho, but these interesting ventures were mere ripples on the calm surface of American apathy, which twenty years ago gave no promise of the full tide of metallurgic advance that since then has swept over base-metal mining in our country.

Another American patent deserves mention as a link between the Elmore bulk-oil process and the later frothing methods. Edmund B. Kirby, in his patent of December 14, 1903, used from 25 to 75 per cent of oil in a flowing pulp, but he depended upon thin oil—kerosene—and upon violent agitation, so that he departed from the Elmore type of flotation. The more interesting feature of his claim was "the injection of a gas, preferably air, into the mass", which statement, if taken with reference to "allowing the hydrocarbon-coated particles to float to the surface of the mass", seems indeed to be a forecast of froth-flotation. Kirby tried his process on a variety of British Columbian ores, but no working-plant was erected; nevertheless he deserves respectful mention in any history of the flotation process.

Then came James M. Hyde; he had been on the staff of Minerals Separation under Theodore J. Hoover, who in 1906, was engaged by Ballot as general manager for his company. In 1911 Mr. Hyde left Minerals Separation, after only one

* T. A. Rickard, 'Interviews with Mining Engineers', p. 125; 1922.

year's service, and went to Montana, at the instance of Mr. Hoover, who likewise had severed his connection with Minerals Separation. Hyde made flotation tests on the zinc-lead ore of one of the Butte & Superior company's mines, at Butte, and erected a trial-plant at Basin in disregard of the Minerals Separation patents. In 1912 Edward H. Nutter, American manager for the Minerals Separation company, erected a 50-ton experimental plant to treat the chalcopyrite ore of the Britannia mine, on Howe Sound, British Columbia, and demonstrated the efficiency of the process, which has been in use at this mine continuously since then.

In October, 1911, a suit for infringement was brought by Minerals Separation against Mr. Hyde, and thus was started a series of litigations that engendered much bitterness. Here it may be noted that the Elmores and Minerals Separation waged war likewise from 1905 to 1914; it was a relentless fight involving charges of bad faith. So also the litigation between Minerals Separation and Hyde had a background of personal animosity arising out of the fact that Messrs. Hyde and T. J. Hoover had been on the staff of Minerals Separation. These cross-currents of ill-will were regrettable in so far as they prevented a reasonable compromise and thereby undoubtedly hindered both the application and the improvement of the process.

The lawsuit against Hyde was based on his infringement of patent No. 835,120, which, as the United States Supreme Court decided,* depended upon the use of a critical amount of oil, less than one per cent on the ore, and upon so impregnating with air the mass of ore and water, by means of violent agitation, as to cause a froth, peculiarly coherent and persistent, composed of air-bubbles with only a trace of oil on them, to rise to the surface, bearing with them a high percentage of the metal and metalliferous particles in the pulp. The District Court of Montana decided against Hyde, the Court of Appeals reversed this decision, but the Supreme Court upheld it.

* T. A. Rickard, 'Concentration by Flotation', p. 105; 1921.

Looking back, it is remarkable that the case should have gone, by writ of certiorari, to the Supreme Court. The Supreme Court's action in granting a submission of the Hyde case was influenced probably by the fact that Minerals Separation just before the application for a writ of certiorari had won its British suit against the Elmores before the Law Committee of the Privy Council in London; it happened that Chief Justice White knew Lord Haldane personally, and had a great respect for his acumen. It is evident, from reading the record, that the judges were not qualified to try this highly technical case, and that the final decision might as well have gone one way as the other. The decision had the effect of putting Minerals Separation well in the saddle and eventually led to a series of adjustments helpful to the application of the process on a large scale. In 1919 Minerals Separation brought suit against the Nevada Consolidated Copper Company for infringement of patent No. 835,120, and in the following year another suit was started against the same company for infringement of patent No. 962,678. Eventually this litigation was dropped when a compromise was made and the company became a licensee. A suit was brought against the Magma Copper Company in 1920, for infringement of patent No. 962,678, but the legal proceedings were so dilatory that the final decision, adverse to Minerals Separation, was not given until 1930, by which time the patent at issue had expired.

The first successful use of the process in the United States was made at Butte, on a zinc-lead ore, as we have seen. The later development of the process was based on the treatment of copper ores, especially the chalcocite disseminated through immense orebodies disclosed in Arizona, Utah, and Nevada. This part of the story begins with the tests made by Minerals Separation in the London laboratory and in plants erected at sundry copper mines in other countries, such as the Caucasus Copper and the Great Fitzroy mines. These early attempts were unsuccessful. In his book, dated July 4, 1912, Theodore J. Hoover refers to the limitations of the process and mentions

both bornite and chalcocite, at Bingham, for example, as giving trouble to flotation methods. In a report made by Hyde, in 1911, it is stated that "the copper ores of a good part of the Southwest and also of at least a portion of the Utah region contain chalcocite, which is not floatable by any of the methods so far tested".* This indicates the opinion held by the Minerals Separation staff at that time. They discovered their mistake in due course. During 1912, in the Minerals Separation laboratory at San Francisco, several tests were made on chalcocite ore from the Inspiration mine, in Arizona, but the results were disappointing. At the end of that year, however, an 87 per cent recovery on a 2 per cent copper ore was obtained in a 15 per cent concentrate. A 50-ton experimental plant was erected forthwith at the mine. The Inspiration company, acting on the advice of Dr. L. D. Ricketts, took out a licence from Minerals Separation in 1913. During March of that year F. A. Beauchamp, of the Minerals Separation staff, obtained a 90 to 92 per cent recovery in a 35 to 40 per cent concentrate from a 2 per cent ore, with a 0·15 to 0·2 per cent tailing. That was a decisive demonstration. In the early experiments the presence of a colloidal kaolinized mineral had diverted the oil from its proper function and had interfered with the recovery of copper, until Chapman suggested the addition of the oil to the ore in the tube-mill, where the mineral particles became oiled at the instant of exposing fresh fractures. These experiments warranted the expectation that on a 1·58 per cent copper ore there would be obtained a 27½ per cent concentrate, giving a recovery of 92 per cent and a tailing loss of only 0·13 per cent of the copper. A 600-ton Minerals Separation test-plant was built in January, 1914; in July of that year a pneumatic equipment consisting of five Callow cells and one Pachuca tank was added, and between August and October a Towne machine was in use. In 1915 the Inspiration Consolidated Copper Company built a mill of 18

* T. J. Hoover, 'Concentrating Ores by Flotation', p. 157; 1912.

sections, each of 800 tons capacity, or a total of 14,400 tons daily. Later this mill treated 21,000 tons per day.

In June, 1914, Chapman started flotation experiments at Anaconda in a 200-ton plant. He obtained a recovery of 90 per cent, using a kerosene-acid sludge made from Californian petroleum and chamber acid, the latter having been found more effective for the purpose than fume acid. Here I may remark that copper is 'recovered' in a concentrate and is then 'extracted' by smelting. The distinction is important in this context. On February 1, 1915, the Anaconda and Inspiration companies signed a joint contract with Minerals Separation by the terms of which they agreed to pay royalty on a scale ranging from 12 cents per ton on 4000 tons daily to 4 cents per ton on the treatment of more than 30,000 tons daily. This was a great winning for the patent-owning company. The tonnage coming under the terms of this agreement included the ore treated by sundry subsidiary mining companies, the consequence being that the maximum tonnage and minimum royalty specified in the agreement were reached by the close of 1916, at which time the Anaconda flotation plant was treating 14,500 tons daily. As an example of the saving made by aid of flotation, it is worth mentioning that whereas the tailing from the water-concentration mill used to assay 0·62 per cent copper, the residue now, after treatment in the flotation annex, assayed only 0·15 per cent on a 3 per cent ore; that is, out of 60 pounds of copper per ton, only 3 pounds was going to waste, as compared with 12·4 pounds formerly. The recovery was 95 per cent. Moreover, the metallurgic improvements made at the Washoe plant during 1915 were so effective as to cause an increase of 55,000,000 pounds per annum in the production of the Anaconda company "without increasing the tonnage or grade of ore that has been mined in the past". So testified John D. Ryan, the president of the Anaconda company, in his annual report.* Further, he stated that "approximately 40,000,000 pounds of this increased production will be

* *Mining and Scientific Press*, Vol. CXII, p. 296; 1916.

made without adding to the cost per ton of ore treated". This was equivalent to the output of a big mine.

Opposition to the Minerals Separation company and questioning of the validity of their patents were not ended, however; and this unwillingness to give them a clear field was stimulated in the United States by what was considered a drastic manner of enforcing their rights, by binding technicians to secrecy, and by efforts to prevent the publication of information on flotation. This opposition to Minerals Separation and their exacting methods, as it seemed, was voiced effectively by the 'Mining and Scientific Press' of San Francisco, which technical periodical also published a great deal of useful information on the subject. The antagonism to Minerals Separation culminated in a complaint to the Federal Trade Commission, which heard the charges in 1920, but, it is fair to say, the evidence was weak and the greater skill of the lawyer for the respondents caused the inquiry to come to nothing.*

Meanwhile litigation was still in progress. The Miami Copper Company, whose mine is adjacent to the Inspiration, undertook to flout Minerals Separation. From December, 1913, to August, 1914, a series of flotation tests were made by R. C. Canby, who used various types of apparatus, including the Minerals Separation agitator and the Towne machine. On August 7, 1914, a pneumatic flotation plant was completed. The remodeled Miami mill, with a capacity of 4200 tons daily, went to work on March 15, 1915. In this plant the Callow machine was introduced. On July 14, 1914, Minerals Separation brought two suits, based respectively on patents No. 835,120 and 962,678, but these suits were dismissed on request of Minerals Separation, and on October 10, 1914, a single suit was started for infringement of three patents, the two already mentioned and No. 1,099,699.

This last patent was not sustained and need not be discussed. No. 835,120 was alleged to have been infringed by the use of the Callow machine, invented by J. M. Callow, of Salt

* *Mining and Scientific Press*, Vol. CXXI, p. 263; 1920.

Lake City. His flotation cell consists of a box with a sloping bottom in which are holes, over which canvas is spread, so that air can be filtered through at the rate required to make a froth. It was claimed by the Miami company that the admission of air without mechanical agitation was a departure from the process of patent No. 835,120, and resembled a device patented by T. J. Hoover in England in 1910, but never patented in the United States. The District Court of Delaware decided that the Miami had infringed, by using less than 1 per cent of oil, and by employing pine-oil, this being a soluble frothing agent such as that of patent 962,678, which had been granted to Sulman, Greenway, and Higgins in 1910. This patent became increasingly important, as the life of 835,120 expired in 1922, and Minerals Separation had to fall back on other patents, of which it had acquired a large number, with the promise of long-continued collections of royalty. The varying solubility of oils and the use of soluble agents for that modification of the surface-tension of water to which the phenomena of froth-flotation or bubble-levitation are so largely due became an important feature of both litigation and mill operation. The idea goes back to William Haynes, who, in his British patent of 1860, used coal-tar from gas-works in a rudimentary process of oil-flotation. Coal-tar contains as much as 20 per cent of soluble products, but Haynes had no more notion of the part they played than Elmore had of the part played by air in his bulk-oil process.

Next we come to an extremely important phase of the process, namely, the modifications known variously as selective, preferential, or differential, all of which contribute to the successful recovery of several kinds of marketable concentrates of the different metallic sulphides constituting the complex ores of lead, zinc, and copper, with their associated precious metals. This phase of flotation fortunately has not been checked by litigation.

At an early stage in the development of the process, especially in Australia, it was discovered that the surface of some of

the sulphide minerals could be altered so as to diminish their ability to float while leaving the surface of the other associated sulphide minerals unaltered and therefore floatable. This research was directed chiefly to the separation of blende from galena. E. J. Horwood rendered galena resistant to flotation by roasting it at a low temperature, while the blende was not affected if the roasting was well controlled. Horwood's American patent was No. 1,020,353 of 1912. The Horwood process was used at the Afterthought mine, in Shasta county, California, by J. T. Milleken in 1917.* Fractional roasting was used also in the North Star mill of the Federal Mining & Smelting Company, near Hailey, Idaho; and another modification of roasting was used by the Progress Mining & Milling Company, near Robinson, Colorado; but none of these preferential operations was on a large scale.

The first mention of the use of dissolved substances for producing a differential effect is contained in British patent No. 23,870 of 1910 and in American patent No. 1,067,485 of 1913, both granted to Edward H. Nutter and Henry Lavers, of the Minerals Separation company. This may be regarded as the first truly 'differential' method. The wording of the patent is vague, purposely. The desired effect is produced, it is said, by means of varying physical conditions and by the use of various soluble froth-forming substances, such as cresol, eucalyptus oil, and by the addition of sulphuric acid. The next method of this kind to be considered is that of H. H. Greenway and A. H. P. Lowry, embodied in American patent No. 1,102,738 of 1914; this consists in treating the ore with a solution of a bichromate either before or during flotation. Such minerals as galena and pyrite will be wetted by this solution, and such minerals as blende, molybdenite, and chalcopyrite can be floated differentially from their association with either pyrite or galena. The inventors of the method soon learned that much better work could be done by performing the flotation in an alkaline pulp, in the presence of a

* A. H. Heller, *Mining and Scientific Press*, Vol. CXIX, p. 151; 1919.

bichromate, and the result of this discovery was embodied in American patent No. 1,142,820 of 1915.

The development of differential methods owed much to the early work done at Broken Hill in the treatment of dump material.* It was observed that under certain conditions the galena and silver sulphide floated less completely than the blende. This may have been caused by the lubricating oil or some other oily substance that got into the mill-circuit. Experiments demonstrated that the sulphide minerals could be made to behave differently. F. J. Lyster took advantage of these hints while at work in the mill of the Zinc Corporation at Broken Hill, and in 1910 he obtained British patent No. 11,939, followed by American patent No. 1,203,372 in 1916, both of these being acknowledged as supplementary to the Nutter-Lavers patents, and both were duly assigned to the Minerals Separation company. Lyster used various reagents, such as lime, calcium sulphate, magnesium chloride, and ferrous sulphate, whereby the galena was caused to float, while the blende remained inert. The zinc sulphide may be caused to float later by continued agitation and aeration of the pulp. Copper sulphate was introduced for the separation of zinc blende, successfully, but the method was not patented and therefore became open to the art, as the lawyers say.

The chief patents now surviving, all owned by the Minerals Separation company, are based upon the use of xanthate salts of the alkaline metals and various alcohols. The Whitworth patents covering the use of phosphocresylic acid and owned by the American Cyanimid Company, have proved important in treating the lead end of zinc-lead ores and some copper ores. The basic xanthate patent is that of Cornelius H. Keller, of the Minerals Separation staff; this is No. 1,554,216, issued in 1925. Corresponding patents are held by the same company in other countries. The effect of xanthate as a flotation agent is to increase the recovery of concentrate and to yield a product that both settles more quickly and is more easily filtered.

* W. Shellshear, *Mining and Scientific Press,* Vol. CXV, p. 613; 1917.

The why and wherefore of these results remain obscure, like most of the physics of flotation.

It is interesting to note that the use of some kind of oil was considered necessary in the early days of the process, and oleic acid was the oil mentioned in the basic froth-flotation patent, No. 835,120. Later, various oils, usually those readiest available, such as pine-oil, camphor-oil, and eucalyptus-oil were introduced. The essential factor in the process is a decrease of the surface-tension of the water, mixed with the pulverized ore, by the addition of a contaminant or modifying agent. For example, the addition of soap to water diminishes the contractile force of surface-tension so as to render the bubbles more persistent. The aim of the metallurgist therefore was to make a coherent and persistent froth that would be capable of levitating the particles of metallic mineral to the surface of the pulp, whence the mineral-bearing product was removed for filtration or dewatering. The oils and chemical reagents added to the pulp have the effect of preventing the wetting of most of the valuable metallic minerals (including sulphur and graphite), by giving them a protective film, whereas the earthy gangue minerals are readily wetted and therefore do not attach to the bubbles. Selective wetting therefore becomes a critical factor in the process. In the course of experimentation it was ascertained that the modification of surface-tension could be effected by soluble frothing reagents other than oils, so that gradually the use of oil was superseded until it has now become a minor factor in the milling process. In 1926 a total of 201,711,795 pounds of various reagents was used in treating 50,889,254 tons of ore in the United States. From this ore a recovery of 3,353,120 tons of concentrate was made, showing a concentration in the ratio of slightly more than 15 to 1. Of the American ores treated by flotation during that year, a little more than 70 per cent were copper ores, and about 15 per cent were zinc-lead ores. Of the total quantity of reagents employed, lime amounted to 162,240,359 pounds; sodium sulphide to 7,354,844 pounds;

pine-oil, 5,980,311; xanthate, 3,983,118; refined coal-tar creosote, 2,777,806; soda-ash, 2,985,867; and sulphuric acid, 4,539,500 pounds.*

Normally the flotation process in the United States is responsible for the metallurgic treatment of 55,000,000 tons of ore annually, the products being extremely diversified and including copper, lead, zinc, silver, molybdenum, and graphite.

* Thomas Varley, *Engineering and Mining Journal,* Vol. CXXV, p. 469; 1928.

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